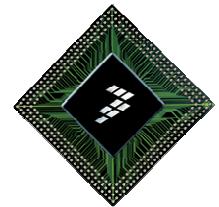


i.MX51 Applications Processor and Linux Hands on

March-2010

Shailendra Miglani

Senior Field Applications Engineer



Agenda

- ▶ Roadmap
- ▶ Features of i.Mx51 Processor
- ▶ i.MX51 Website
- ▶ i.MX51 EVK
- ▶ Linux BSP release packages
- ▶ Installing and Building LTIB (Exercise 1)
- ▶ NFS on i.Mx51 (Exercise 2)
- ▶ Creating a hello world application from scratch (Exercise 3)

i.MX General Embedded Roadmap

Cortex A8

ARM11

ARM9

Associated
PMIC:
MC13783

i.MX31

- OpenGL ES 1.1 3D

i.MX31L

- ARM1136, 400 MHz
- USB (High Speed)
- Video Encode VGA

i.MX27

- D1 Video Encode
- D1 Video Encode

i.MX27L

- ARM926, 400MHz
- Ethernet, mDDR

Associated
PMIC:
MC13892

i.MX357

- Open VG 1.1
-
- i.MX353
- ARM1136, 532 MHz
- Ethernet, DDR2
- USB Phy x 2, CAN x 2

i.MX258

- Security

i.MX257

- Touchscreen
- CAN x 2

i.MX253

- ARM926, 400MHz
- Ethernet, DDR2
- USB Phy x 2

i.MX515

- Open VG 1.1
- OpenGL ES 2.0
- Security

i.MX513

- HD720p Video Decode
- D1 Video Encode

i.MX512

- Cortex A8, 800MHz
- Ethernet, DDR2, USB Phy

Associated
PMIC:
MC34704B

i.MX233

- ARM926, 450MHz
- Touchscreen
- Integrated PM, Audio

Next Gen

Next Gen

2009

2010

2011

In Development

Freescale Applications Processor Value Proposition

- ▶ Performance (MHz & Memory Efficiency)
- ▶ Low Power (Audio < 18 mW system, HD720 Video < 250 mW)

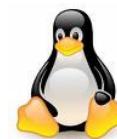


- ▶ State of the art Audio, Video, Graphics and Codecs

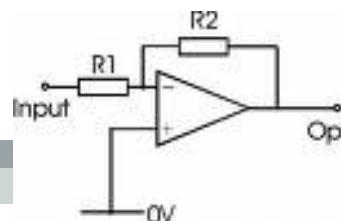


- ▶ Consistent and scalable architecture

- ▶ Complete OS/SW platform



- ▶ Mixed signal integration

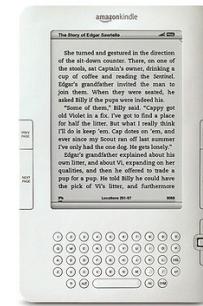


Freescale Mobile Consumer Leadership

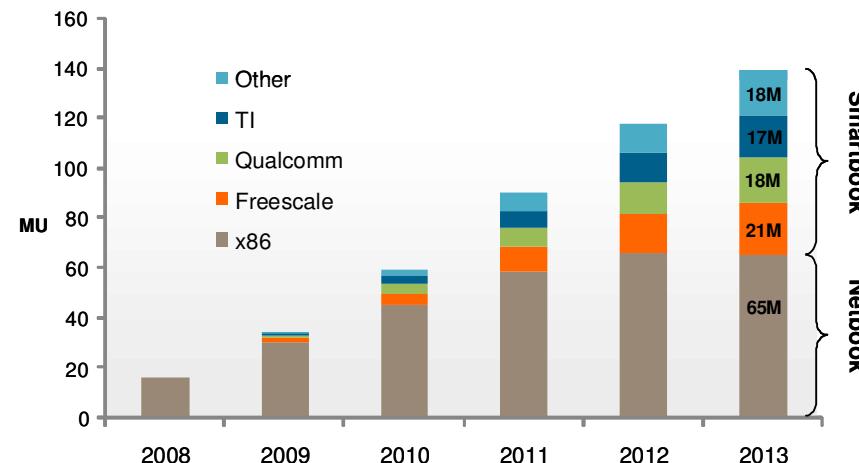
- ▶ Pioneer in the portable media player market



- ▶ #1 market share in eBook application processors



- ▶ Shaping the smartbook product category



Source: ABI Research April 2009



i.MX51 Family Target Markets

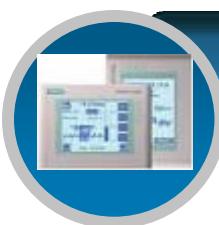
Product Launch November 4

The i.MX51 brings a new level of performance and integration to the i.MX family from Freescale, while maintaining the family's commitment to low power consumption, product accessibility and device longevity.



Consumer

- ▶ Smartbooks
- ▶ eBooks
- ▶ Portable Media Player
- ▶ Media Phone/Terminal
- ▶ Digital Photo Frame
- ▶ High-End Appliances
- ▶ Digital Signage
- ▶ Printers



Industrial

- ▶ Security and Surveillance
- ▶ Advanced HMI
- ▶ Medical
- ▶ Factory Automation



Automotive

- ▶ Infotainment Systems
- ▶ Navigation
- ▶ Telematics
- ▶ Instrument Cluster

Freescale extends its i.MX51 family to new markets with four processors based on ARM Cortex™-A8 technology

AUSTIN, Texas – Nov. 4, 2009

i.MX51 Key Advantages

Performance

- ▶ The i.MX51 family of processors runs on the powerful ARM Cortex-A8 core at speeds up to 800 MHz, which allows for roughly 2 MIPS per MHz. In addition, the i.MX51 processor offers flexible memory support for mDDR, SDRAM, SLC/MLC NAND, popular lower-cost DDR2, a NEON™ co-processor and VFPU. The high performance of the i.MX51 family of processors enables life-like video and 3-D graphics reproduction and quick response times needed for advanced user interfaces and sophisticated video processing - the building blocks to power the next great applications.

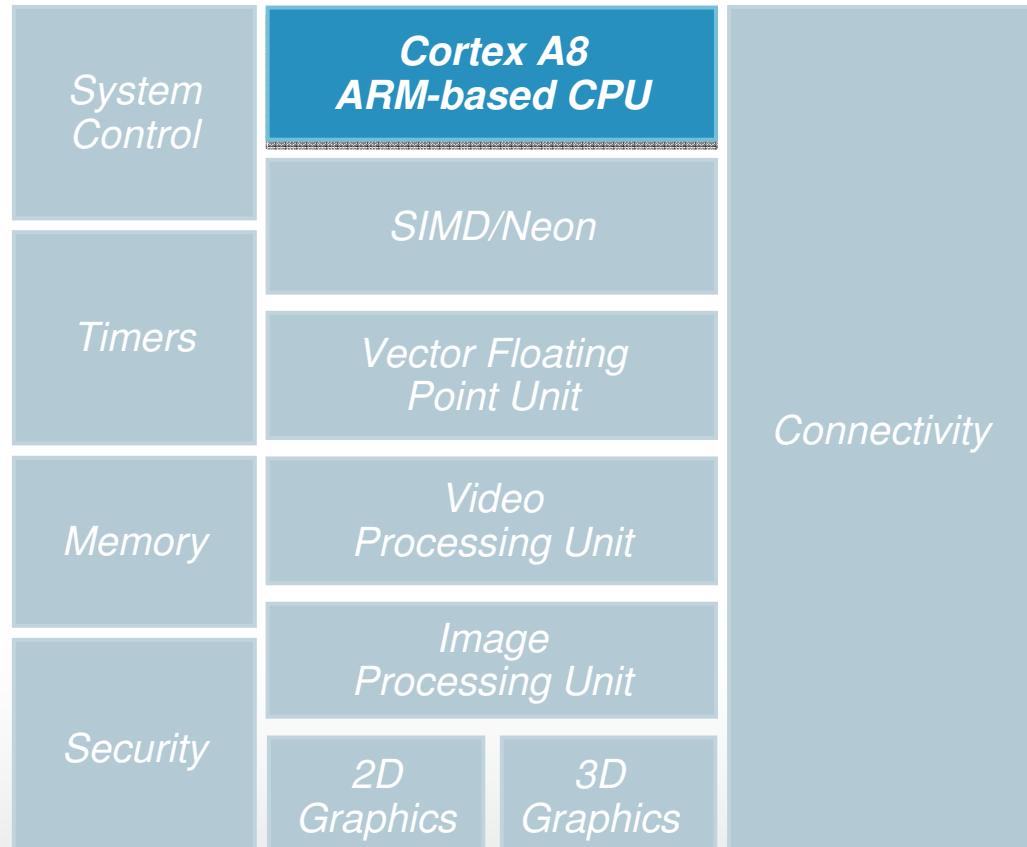
Integration

- ▶ The i.MX51 products integrates five engines including the ARM Cortex-A8 processor, Open VG™, OpenGL®-ES, D1 video encode/HD720 decode and ARM NEON™ technology. Depending on the intended application, different engines are enabled to achieve maximum performance/power ratios for each application space. This exceptional integration simplifies and shortens design time.

Low Power Consumption

- ▶ The i.MX51 delivers extreme performance and low power consumption, helping developers design products that meet today's demands for energy efficiency. Advanced power management features used throughout the i.MX51 processor enable a rich suite of multimedia features and peripherals while maintaining minimal system power consumption in both active and low-power modes, which provides device end-users with long, long play times for hours of work or entertainment use.

i.MX51 Applications Processor

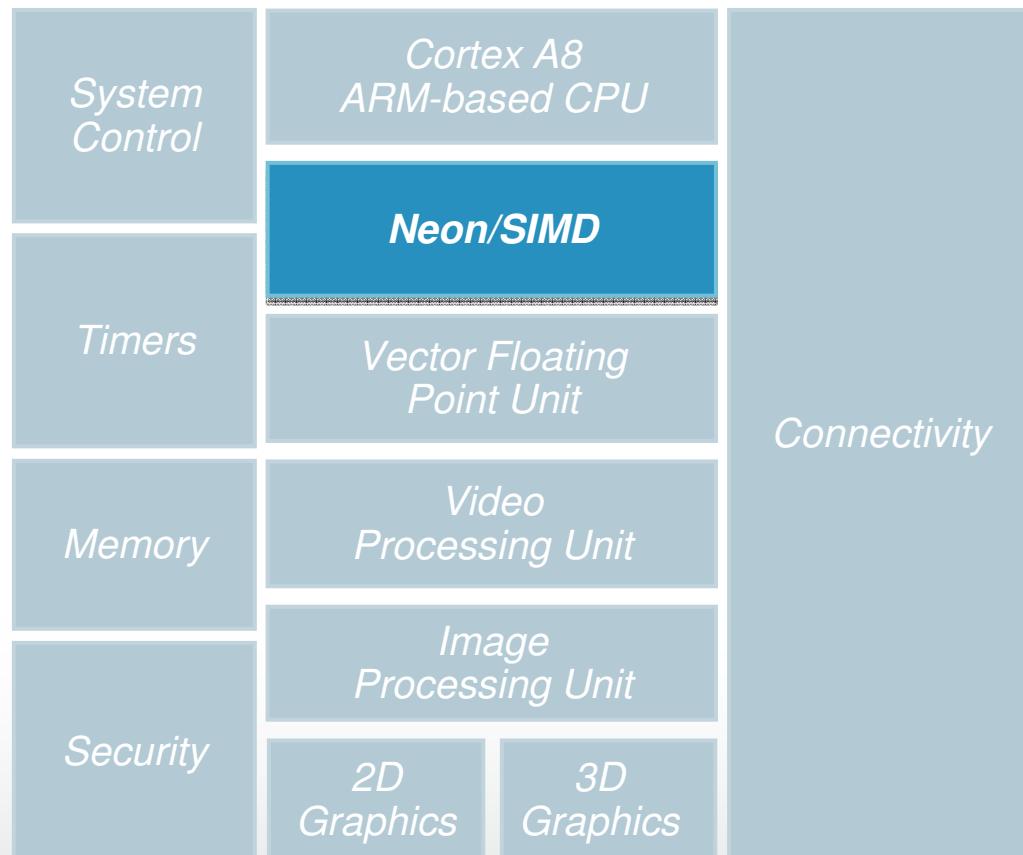


ARM-based CPU

- 800 MHz performance
- Open OS execution
- Web browsing
- Voice recognition
- Navigation map rendering



i.MX51 Applications Processor

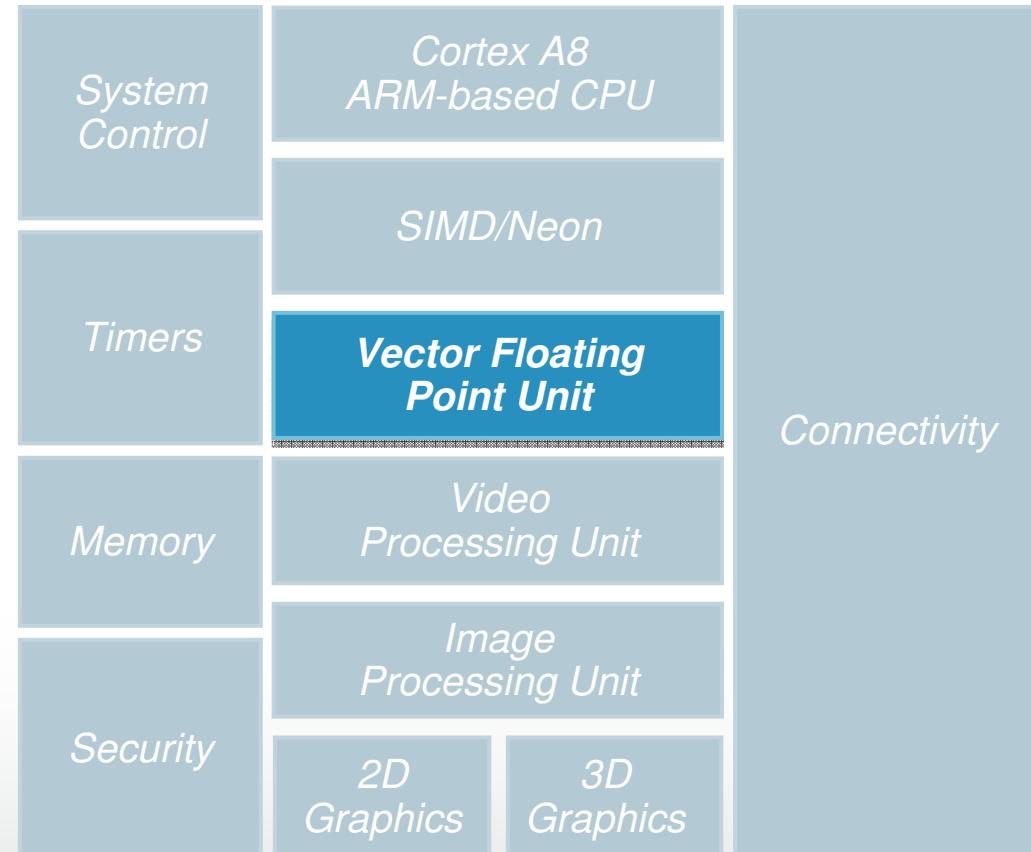


Neon/SIMD DSP

- Audio and speech codecs
- Music playback and recording
- Speech recording
- Image processing



i.MX51 Applications Processor

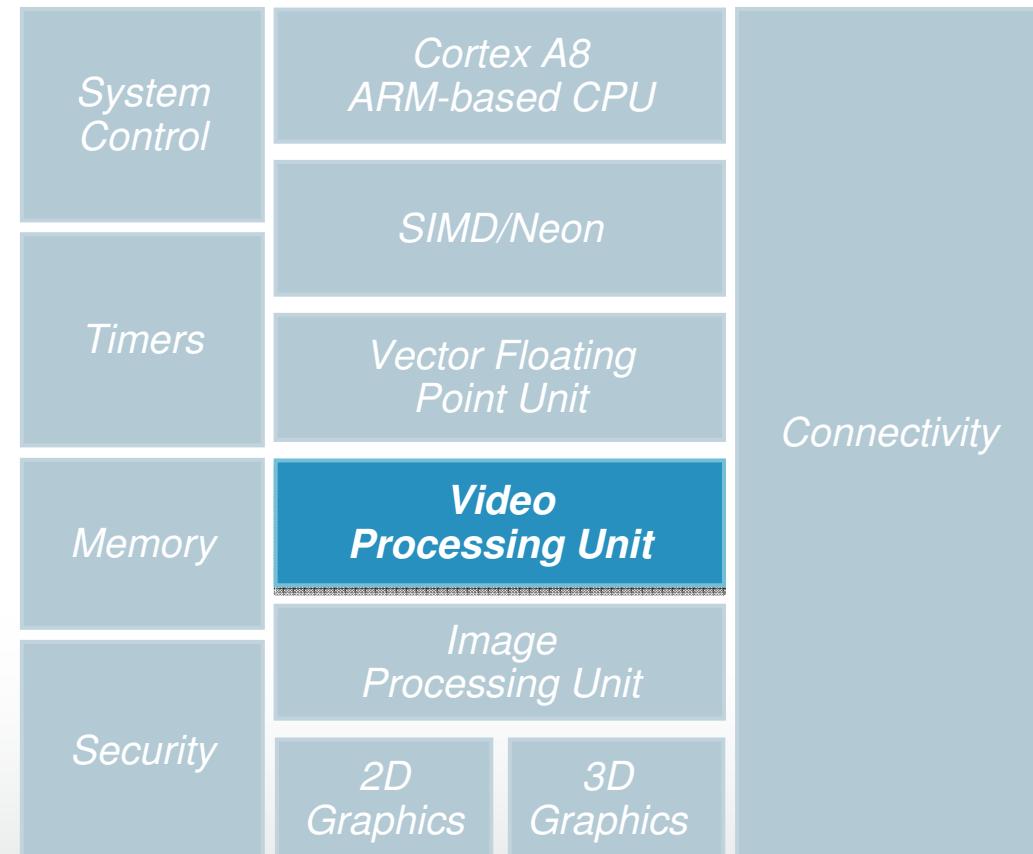


Vector FP DSP

- Acoustic echo cancellation
- Noise suppression



i.MX51 Applications Processor



Video Processing Unit

- Multi-standard video playback/record
- Video telephony
- Video transcoding
- You Tube, Skype, Hulu



i.MX51 Applications Processor

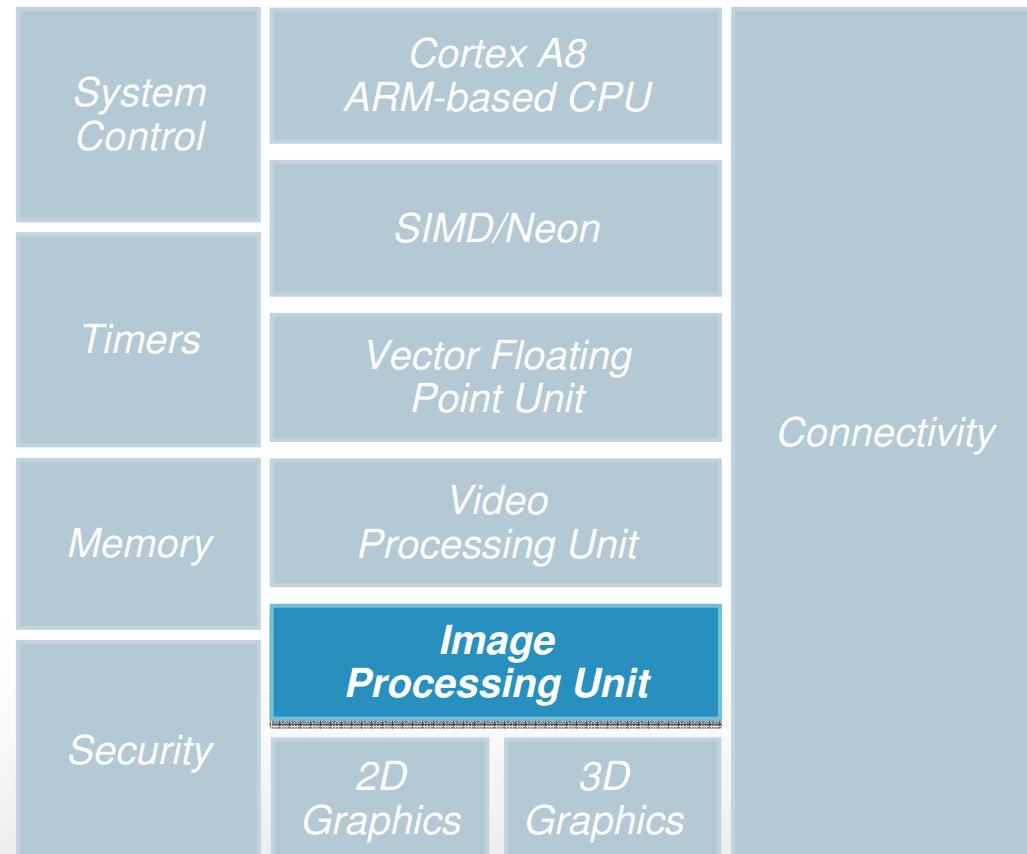
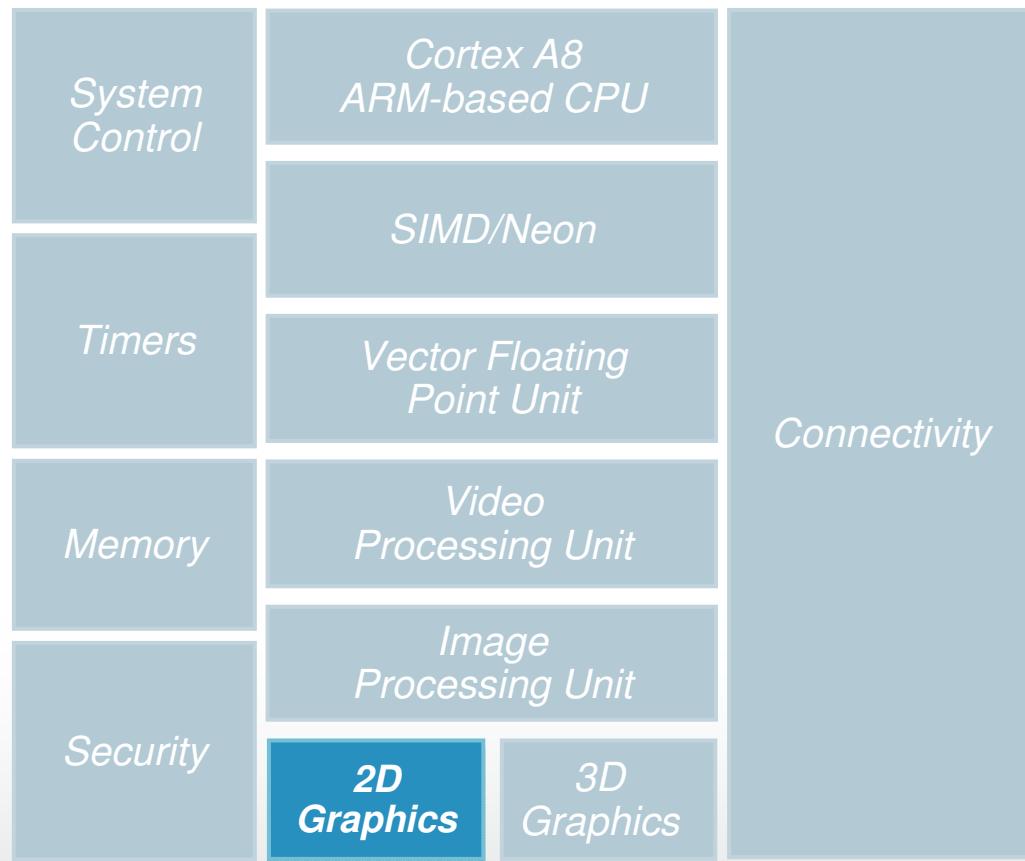


Image Processing Unit

- Image processing routines like scaling, rotation and post-processing
- Photo editing
- Multiple display output
- Multiple camera input



i.MX51 Applications Processor

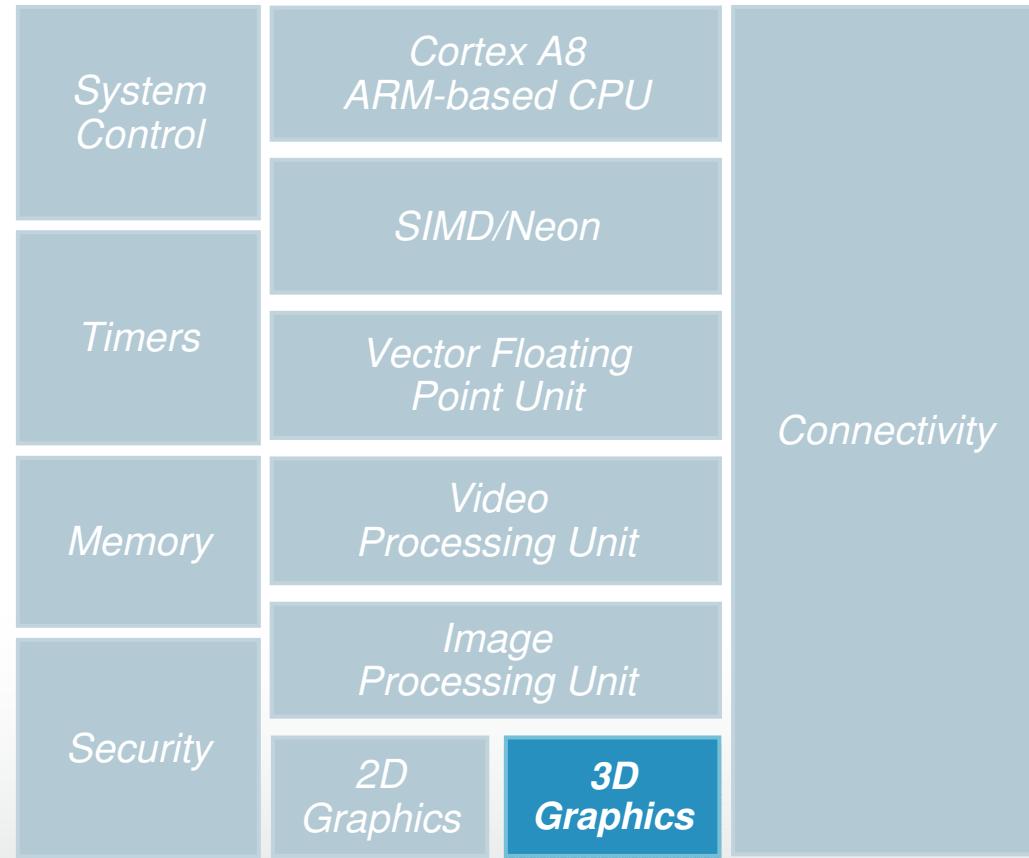


2D Graphics

- Open VG support
- VG accelerated web browsing (both Flash lite/silverlight and page render)
- Map display with both 3D and VG views
- Enhanced Music and album visualization
- X window system acceleration
- Ebook PDF



i.MX51 Applications Processor

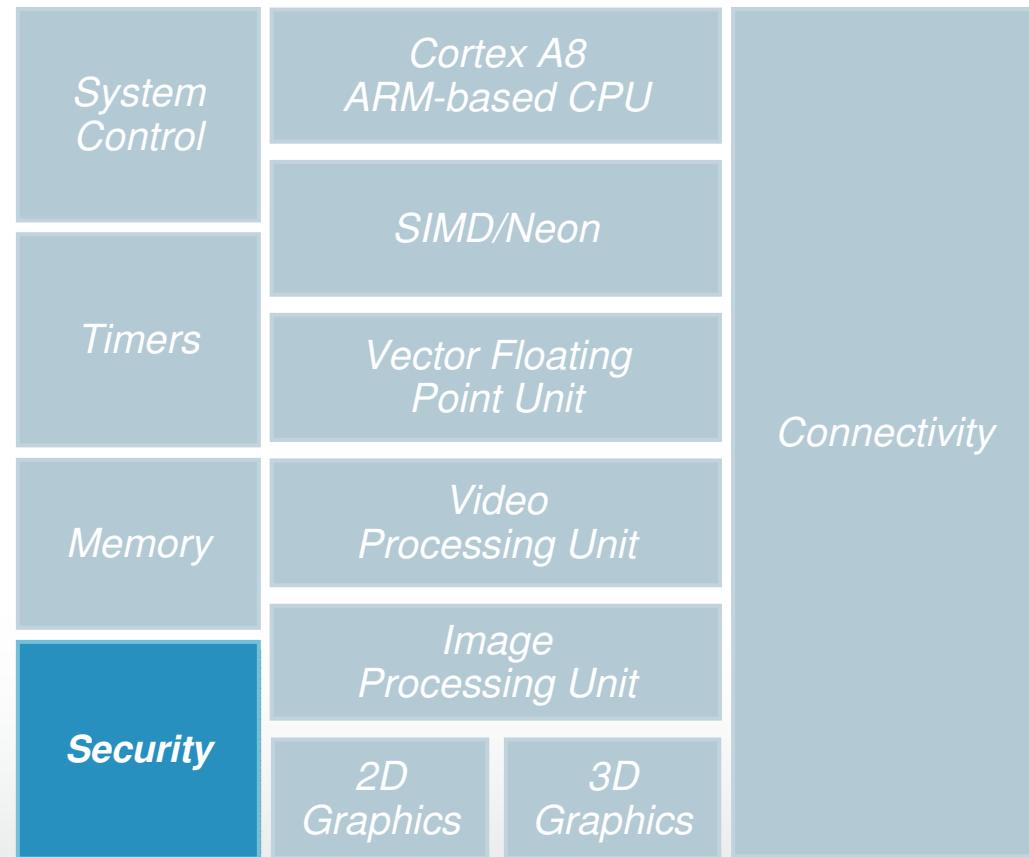


3D Graphics

- OpenGL ES support
- Advanced UI
- Flash 10 acceleration
- 3D navigation
- Gaming
- Excellent YouTube experience



i.MX51 Applications Processor



Security

- Hardware security accelerators
- Secure boot
- Cryptographic accelerators
- Tamper detection
- Secure financial transactions



i.MX51 Family: 3-Digit Part Numbering

Feature	i.MX512	i.MX513	i.MX514	i.MX515	i.MX516
Target Markets	Consumer, Industrial	Consumer & Industrial	Automotive	Industrial & Consumer	Automotive
Target Segments	<ul style="list-style-type: none"> ▶ Factory Automation (Ethernet) ▶ HMI ▶ Portable/Tethered Printers ▶ Medical devices ▶ Ebooks 	<ul style="list-style-type: none"> ▶ IP Camera ▶ Media Phones ▶ Digital Signage ▶ HMI (home appliances, etc) ▶ Medical devices 	<ul style="list-style-type: none"> ▶ Navigation ▶ Advanced HMI ▶ Instrument Cluster ▶ Telematics 	<ul style="list-style-type: none"> ▶ Smartbook ▶ Mobile internet devices ▶ PMPs ▶ Secure Devices ▶ Advanced HMI ▶ High-end PDAs 	<ul style="list-style-type: none"> ▶ Infotainment ▶ Rear Seat Entertainment
Core	Cortex™-A8	Cortex™-A8	Cortex™-A8	Cortex™-A8	Cortex™-A8
CPU Speed	Consumer: up to 800 MHz Industrial: up to 600 MHz	Consumer: up to 800 MHz Industrial: up to 600 MHz	Up to 600 MHz	Consumer: up to 800 MHz Industrial: up to 600 MHz	Up to 600 MHz
Key Differences	<ul style="list-style-type: none"> ▶ DDR2 ▶ Integrated USB Phy's ▶ Integrated Ethernet ▶ Vector Floating Point ▶ HD 720 TV-Out 	<ul style="list-style-type: none"> ▶ i.MX512 + ▶ HW Video Codec: Multi-format D1 video encode & multi-format HD720 decode 	<ul style="list-style-type: none"> ▶ i.MX512 + ▶ OpenGL ES 2.0 3D accelerator ▶ OpenVG 1.1 graphics accelerator ▶ Security: Sahara v4 & Trust Zone 	<ul style="list-style-type: none"> ▶ i.MX513 + ▶ OpenGL ES 2.0 3D accelerator ▶ OpenVG 1.1 graphics accelerator ▶ Security: Sahara v4 & Trust Zone 	<ul style="list-style-type: none"> ▶ i.MX514 + ▶ HW Video Codec: Multi-format D1 video encode & multi-format HD720 decode
Package	0.8mm 529BGA 0.5mm 527BGA	0.8mm 529BGA 0.5mm 527BGA	0.8mm 529BGA 0.5mm 527BGA	0.8mm 529BGA 0.5mm 527BGA	0.8mm 529BGA 0.5mm 527BGA
Positioning	High end processor	Video supported	Automotive support for graphics and security	Full featured: Video, graphics and security	Full featured: Video, graphics and security
10KU Suggested Disty Resale 2010	Contact FSL Sales	Contact FSL Sales	Contact FSL Sales	Contact FSL Sales	Contact FSL Sales
OS	Linux, WinCE RTOS	Linux, WinCE RTOS	Linux, WinCE, RTOS	Linux, WinCE, RTOS	Linux, WinCE, RTOS
General Availability	Consumer: Now Industrial: May 2010	Consumer: Now Industrial: May 2010	April 2010	Consumer: Now Industrial: May 2010	April 2010

Because of an order from the United States International Trade Commission, BGA-packaged product lines and part numbers indicated here currently are not available from Freescale for import or sale in the United States prior to September 2010: i.MX51 0.5 mm pitch packages

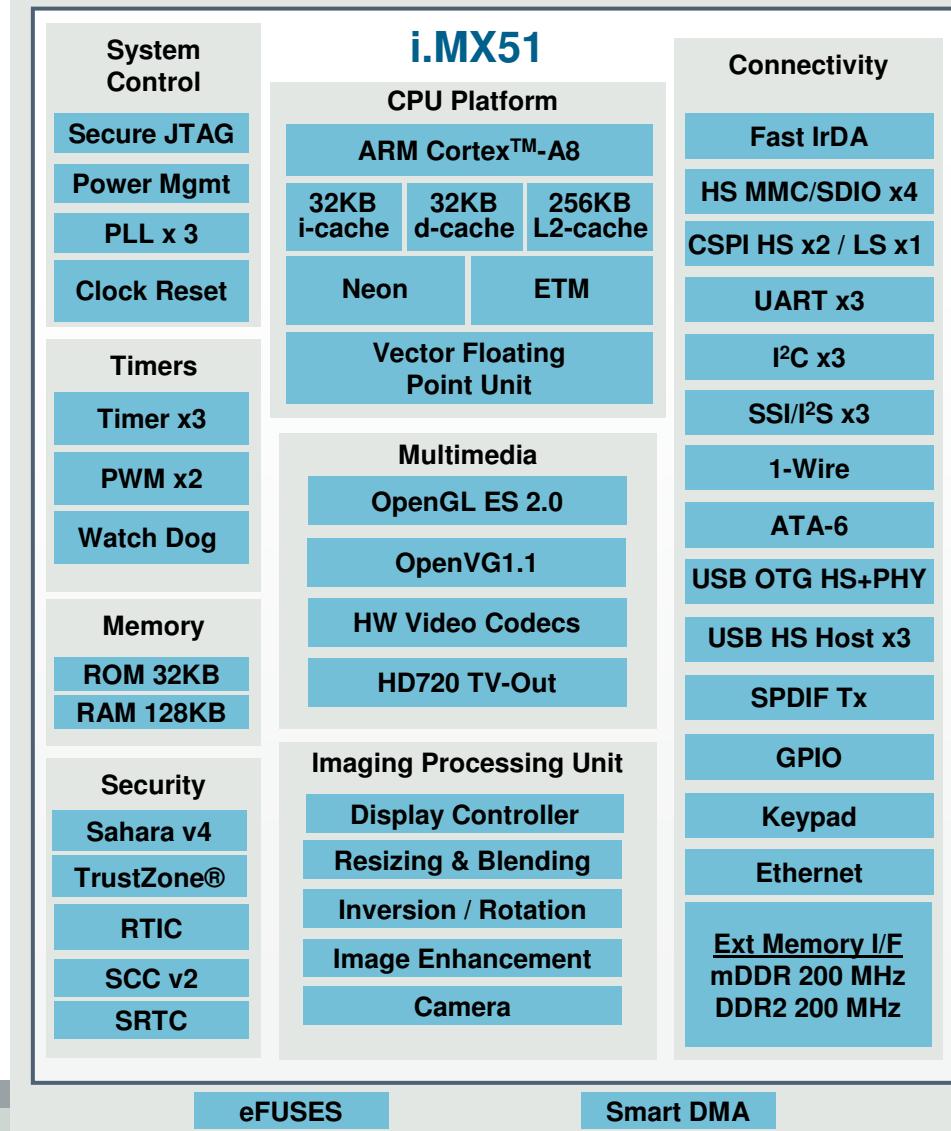
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Specifications:

- **CPU:** Cortex A8, up to 800MHz
- **Process:** 65nm, LP/GP
- **Core Voltage:** 0.8-1.15V
- **Package:** 19x19 0.8mm
- **Temp Range:** -20 to 70C* (consumer)
-40 to 85C* (industrial)
-40 to 85C* (Auto)

* See Datasheet for case/junction temperatures

i.MX51 Family Applications Processor



Key i.MX51 Features and Advantages

- High performance CPU: Cortex A8
- Low power multimedia
- Delivers rich graphics and UI in HW
 - OpenGL ES 2.0 3D accelerator (AMD Z430)
 - OpenVG 1.1 graphics accelerator (AMD Z160)
 - Neon Vector floating point co-processor
 - Display up to WXGA
- Drives high resolution video in HW
 - Multi-format D1 video encode
 - Multi-format HD720 video decode
- Mixed signal integration - HD720 TV out and high speed USB with embedded PHY

Available Parts

- i.MX512, i.MX513, i.MX514, i.MX515, i.MX516

Availability:

- **Market:** Consumer, Industrial & Auto
- **Sample:** Now
- **Production:** Now (C), April'10 (A)
May'10 (I)

i.MX51 Applications Processor

CPU

- ARM Cortex-A8 w/ Neon
- 32KB L1 (Instruction and Data cache)
- 256KB L2 cache

Multimedia *

- Encode – D1 30fps (MPEG4 SP, H.264 BP, MJPEG)
- Decode – HD720 30fps (MPEG2 MP, MPEG4 ASP, H.264 HP, VC-1 AP, DivX, RV10)
- Graphics – OpenVG1.1, OpenGL ES 2.0 @ 27M Tri/sec
- TV Encoder – Component, Composite or S-Video out at 720p

Camera

- Camera sensor I/F (x2)
- Up to 8Mpixel @ 15fps, Up 133Mpixel/sec
- Resizing, Inversion, Rotation
- Color Space conversion, video/graphics combining

Display

- Up to WXGA display - 24 bit @ 60fps
- Secondary Display Support

* Dependent on processor

Connectivity

- High speed USB OTG w/ embedded Phy, Host HS x3
- MobileDDR, DDR2 (Up to 200MHz bus speed)
- SLC/MLC NAND Flash 8/16-bit, NAND/NOR
- High speed MMC\SDIO, UART, I2C, SPI
- ATA-6
- 3.3V support on HD, SDIO, and SIM I/F
- Ethernet controller

Security *

- TrustZone
- AES, DES/3DES, SHA-1, SHA-224, SHA-256
- Run time integrity checker (RTICv3)
- Secure High Assurance Boot
- Security Controller (SCC), including Secure RAM and Security Monitor
- Random Number Generator Accelerator (RNGA)
- Secure JTAG Controller (with electrical fuses)
- Secure real-time clock
- Universal Unique Identification
- Tamper Detection

Power Management

- Advanced power management (DVFS)
- State retention power gating
- Multiple independent clock and power domains

Best in Class Balance of High Performance and Low Power

► SoC

- 65nm technology
- Mix of Low Power (low leakage) and General Purpose (high performance) transistors
- Allows high performing CPU with minimal SoC power consumption
- Hardware acceleration of all performance intensive multimedia tasks independent of CPU

► ARM CPU design

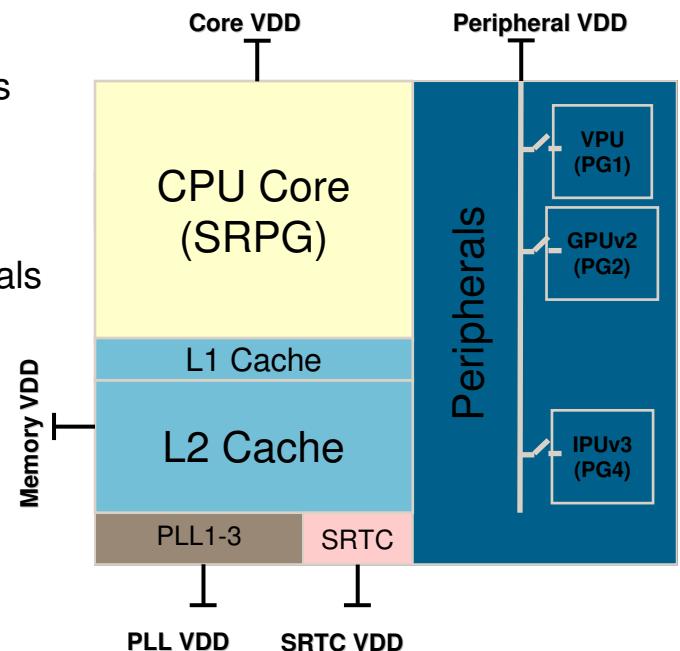
- High speed (up to 800MHz @ 1.15V)
- Low operating voltage (down to 0.8V, 167MHz)
- State Retention Power Gating to reduce leakage in GP process
- L2 cache for minimized access to external memory, reducing the power consumption and increasing performance

► Dynamic Voltage & Frequency Scaling (DVFS)

- Two independent domains with h/w monitoring: CPU, Peripherals

► Hardware Accelerator Power Gating

- Unused accelerators can be dynamically power gated to reduce leakage current



i.MX51 Graphics

► Native OpenGL ES 2.0 3D based on ATI/AMD Unified Shader Architecture

- Same architecture and same content tools as in Xbox 360 and AMD's PC graphics chips
- Licensed by several industry leaders, providing for a strong foundation for a content creation ecosystem
- Binning architecture provides for low memory/power requirements
- 27 M triangles / sec
- 166 M pixels / sec raw performance (1 pixel / clock)
 - 500 M pixels / sec (effective w/ 3x overdraw)



► A native OpenVG 1.1 2D hardware implementation

- Driving high-quality UIs and Flash based internet browsing with extremely low power consumption
- Free 16x antialiasing for very high-quality fonts and graphics
- Capable of delivering a full 3D user interface experience beyond anything on the market today with a fraction of the power consumption compared to any other solution
- 166 M pixels / sec raw performance (1 pixel / clock)



MC13892 Power Management & User Interface IC

For questions, please work with your local Freescale sales person

POWER & BATTERY

- 4 multi-mode buck switchers – 1.05A, 3x800mA programmable outputs, 2 with DVS/DPTC interface
- 2 boost switchers – 5V, 28V adaptive
- 12 LDO regulators, 4 GPOs, power gating
- Main battery & coincell chargers, GP ADC
- Series WLED backlight drivers (main/aux, keypad)
- 1 bank RGB drivers, charger LED drive
- Standalone battery charging with auto disable if battery is out of temperature range
- Standby / user off configurations
- Coulomb counter

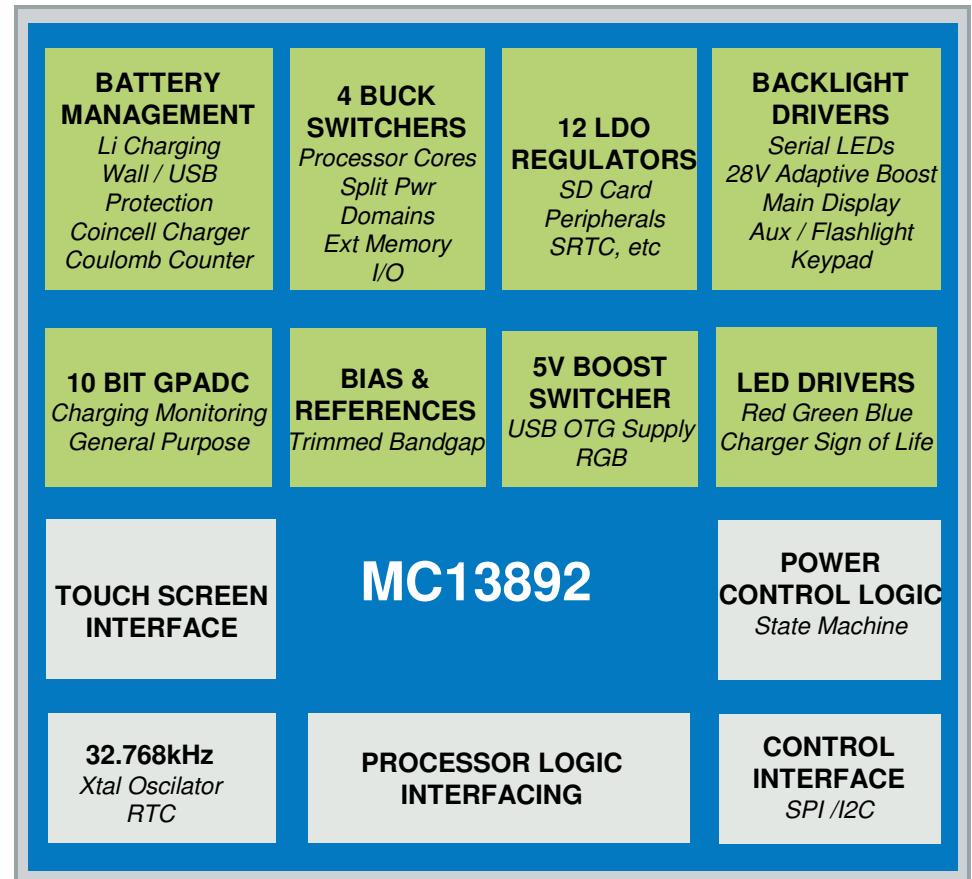
INTERFACE & CONTROL

- SPI / I2C control & register interface
- Resistive touch screen
- 32KHz crystal oscillator, real time clock / calendar alarms
- Package
 - 7x7mm BGA, 0.5mm pitch, 139 pins
 - 12x12mm BGA, 0.8mm pitch, 186 pins

Part Numbers

MC13892JVK 7x7 mm

MC13892JVL 12x12 mm



MC13892 Key Features, Benefits & Advantages

Features	Advantage	Benefit
High level of integration	Reduces size, weight and design time to speed time to market. Integrates both user interface and power functions	Reduces the need for separate design and allows the use of cost effective display technologies
Optimized for use with the i.MX family of processors	Freescale's mixed signal process technology allows for analog, digital and power circuitry on the same IC	Created with input from i.MX design engineers the device is ideal for use with i.MX35 and i.MX51 applications processors. Meets systems expectations for power and software.

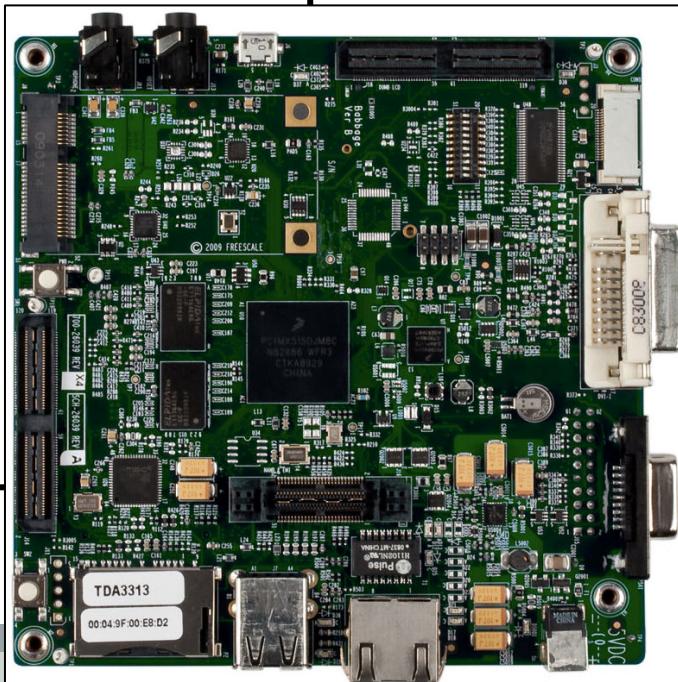
i.MX51 Evaluation Kit (EVK) - \$699 Resale

Single Board Development Platform – Price, Performance, Personality

i.MX51 Evaluation Kit Features

- ▶ i.MX51 Applications Processor (529 BGA)
- ▶ 4 x 128MB DDR2
- ▶ 4MB SPI NOR
- ▶ PMIC – Atlas APL (MC13892JV or MC13892JVL)
- ▶ NAND and EIM Header
- ▶ Debug Serial Port
- ▶ JTAG
- ▶ Reset, boot switches
- ▶ Debug LED
- ▶ Power Source
- ▶ Power on/off button
- ▶ Power Measurement Header

Board size =
5" x 5"



- ▶ 7" WVGA Touchscreen LCD Display (add-on module)
- ▶ Expansion board (add-on module)
- ▶ 2 LVDS connectors
- ▶ DVI-I connector
- ▶ 2 SD/MMC Card Slots
- ▶ USB Host x2 / USB OTG x1
- ▶ Ethernet Port
- ▶ Mini PCIe
- ▶ SATA HDD connector
- ▶ SIM Card connector
- ▶ Keyboard connector
- ▶ Mic input, stereo headphone output (jack), V2IP Headphone
- ▶ Speaker connector
- ▶ USB Camera connector
- ▶ PS-2 TP connector
- ▶ RGB output through DVI-I connector
- ▶ Expansion Header
- ▶ Ambient light sensor footprint
- ▶ FM receiver footprint

MCIMX51EVKJ
www.freescale.com/imx51evk

i.MX51 LCD & Expansion Board

- ▶ i.MX51 LCD module
- ▶ MCIMX51LCD
- ▶ \$250 Resale
- ▶ CPT 7" WVGA with resistive touch screen



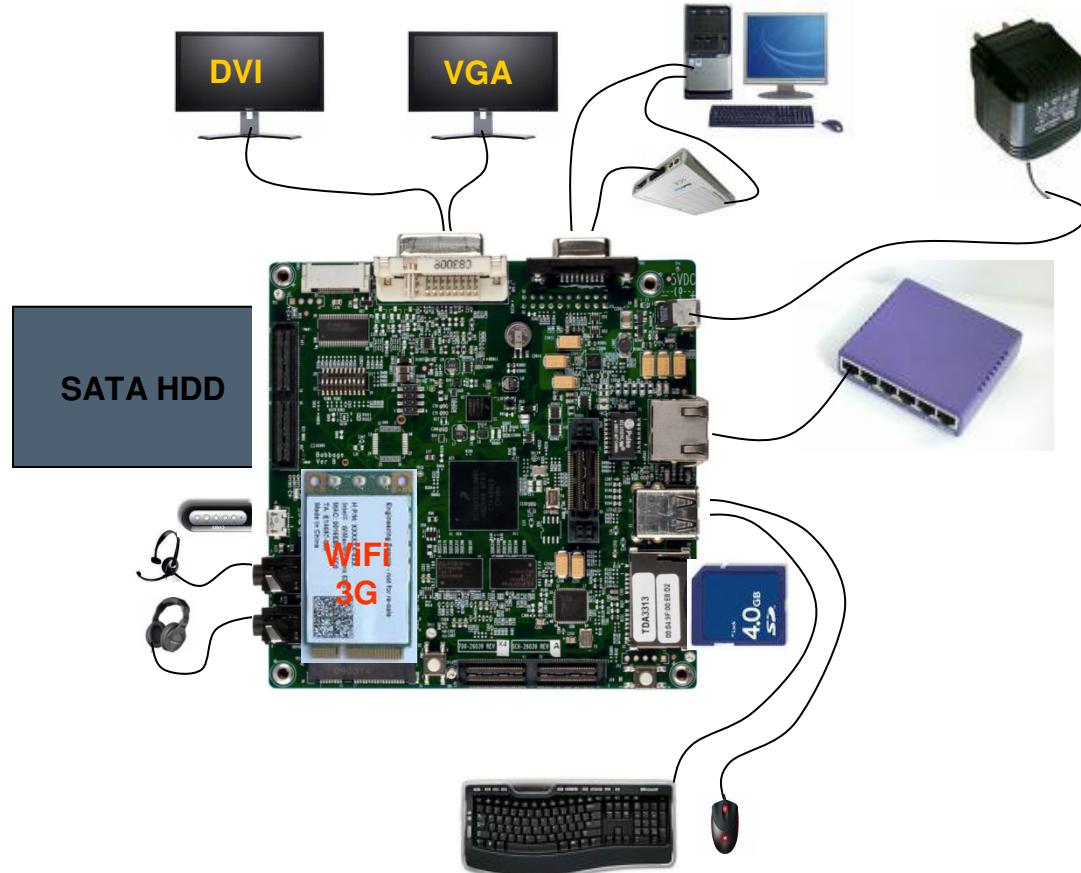
- ▶ i.MX51 Expansion Board
- ▶ MCIMX51EXP
- ▶ \$200 Resale
- ▶ Features



- CMOS Camera
- TV out
- Keypad
- UART



MCIMX51EVKJ : A True SBC (Single Board Computer)



Smartbook = Best of Two Worlds?

PC /
Laptop / Netbook

Smartbook
(4" - 7" LCD)

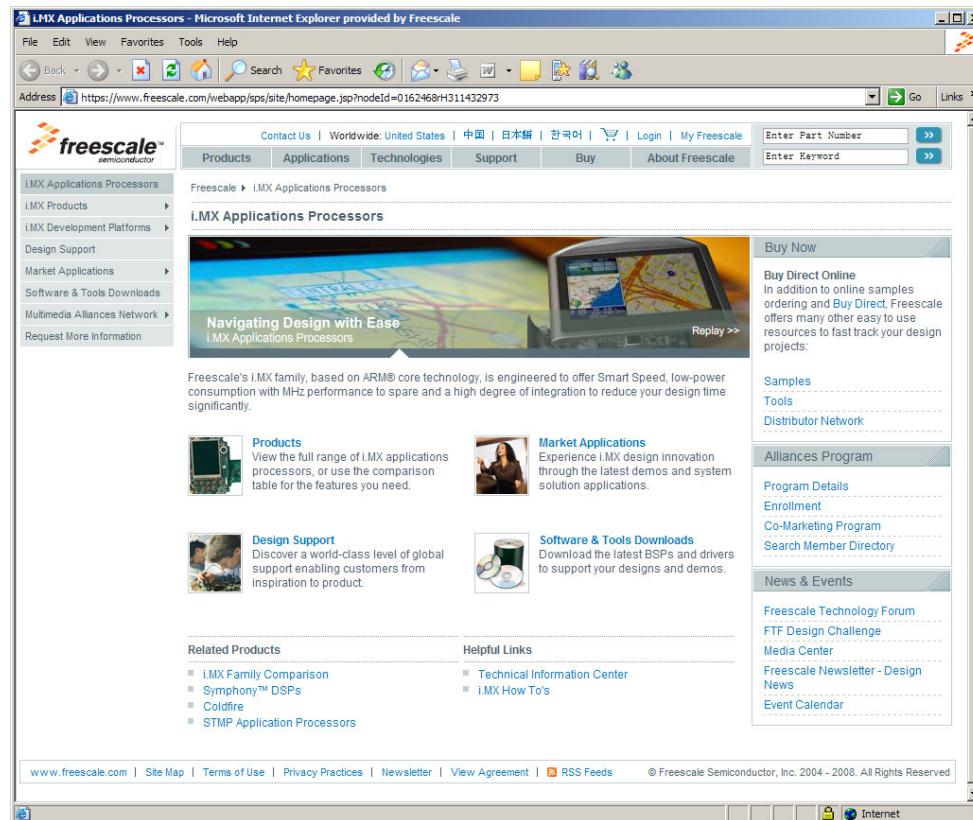
Phone / Smartphone



Can Smartbooks bring back **innovation** and **excitement** to the computing industry by effectively seeding a new category combining the best of two worlds?

i.MX Web Resource

- http://www.freescale.com/webapp/sps/site/homepage.jsp?code=IMX_HOME&tid=vani_mx



- Could send information request to: support@freescale.com

i.MX51 Information

http://www.freescale.com/webapp/sps/site/taxonomy.jsp?code=IMX51_FAMILY

The screenshot shows a Microsoft Internet Explorer browser window displaying the Freescale website. The title bar reads "i.MX51 Processors - Microsoft Internet Explorer provided by Freescale". The address bar shows the URL "http://www.freescale.com/webapp/sps/site/taxonomy.jsp?code=IMX51_FAMILY". The page header includes the Freescale logo and navigation links for "Contact Us", "Worldwide: United States | 中国 | 日本", and "Products", "Applications", "Technologies", "Support". A user profile dropdown shows "Zhengguo's Freescale" and "Login". The main content area is titled "i.MX51 Processors" and discusses "Consumer and Industrial applications" and "Automotive ap...". On the left, a sidebar menu lists "i.MX Applications Processors" with options for "i.MX21 Processors", "i.MX23 Processors", "i.MX25 Processors", "i.MX27 Processors", "i.MX31 Processors", "i.MX35 Processors", "i.MX37 Processors", "i.MX51 Processors" (which is circled in red), "i.MXS Processors", "Documentation", and "Software & Tools".

i.MX51 IC Document

- http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=i.MX515&fpst=1&tab=Documentation_Tab

The screenshot shows a web browser window for the i.MX51 Product Summary Page. The URL in the address bar is http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=i.MX515&fpst=1&tab=Documentation_Tab. The page title is "i.MX51 Product Summary Page - Microsoft Internet Explorer provided by Freescale". The navigation menu at the top includes "Overview", "Documentation" (which is selected), "Software & Tools", "Buy / Parametrics", and "Training & Support". Below the menu, there are links for "Data Sheet", "Application Notes", "Buy", and "Sample". A sidebar on the left titled "Refine Your Results" shows a list under "Show: Documentation - (7)" with items: "Data Sheets - (1)", "Errata - (1)", "Application Notes - (1)", "Reference Manuals - (1)", and "Fact Sheets - (3)". Under "Sub Topics", there are "Device Type" and "Industry" options, with "Expand All" text next to "Industry". The main content area shows "Results 7" and "Featured Documentation" with links to "IMX51 Consumer and Industrial Fact Sheet", "i.MX51 EVK Fact sheet", and "i.MX51 Applications Processors for Consumer and Industrial Products Data Sheet". This data sheet is listed in a table:

ID and Description	Type	Format	Size K	Rev #	Date Last Modified	Download File
IMX51CEC i.MX51 Applications Processors for Consumer and Industrial Products Data Sheet	Data Sheets	pdf	3644	1	11/2/2009	Download

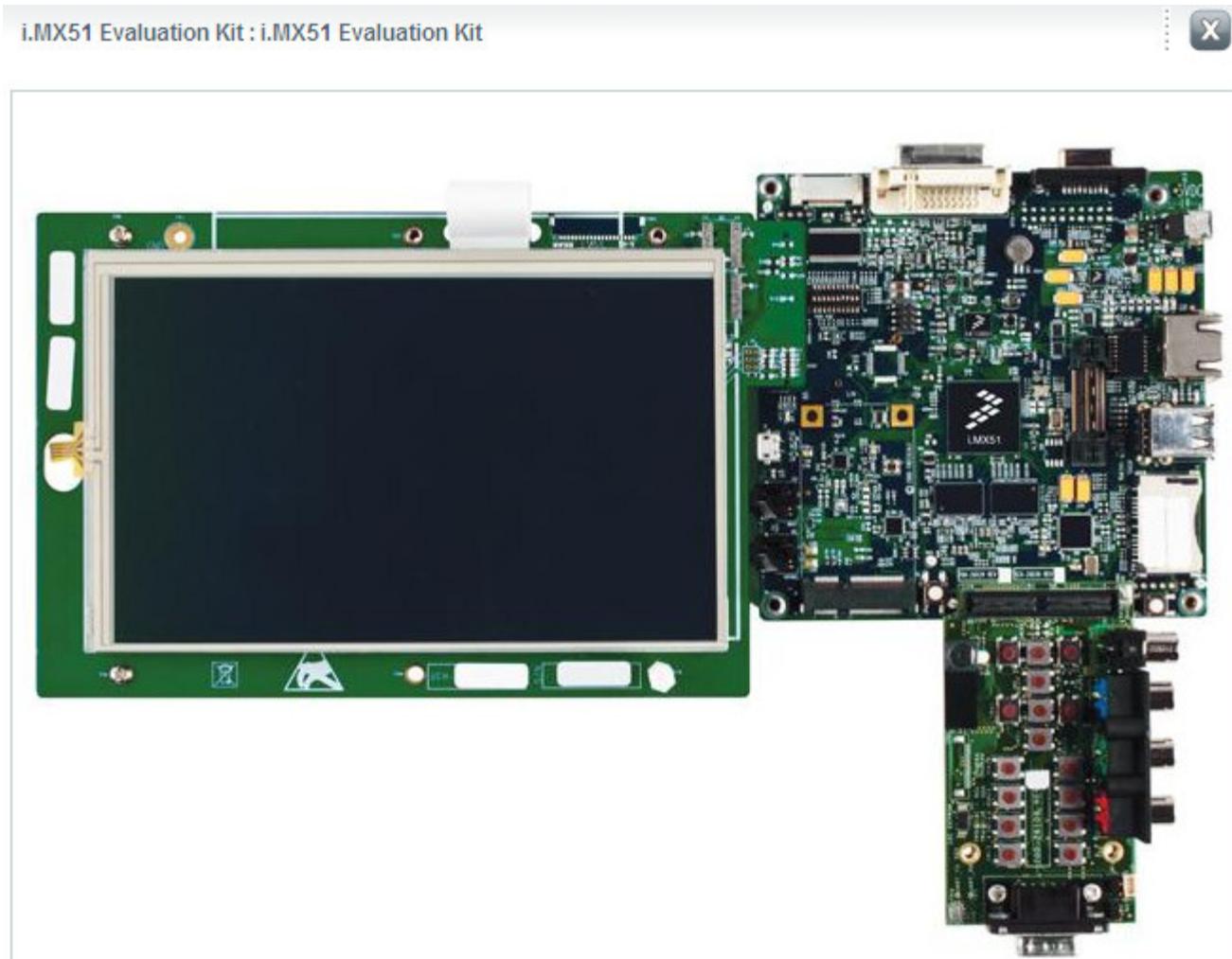
i.MX51 EVK(Babbage)

- i.MX51 EVK(Babbage)

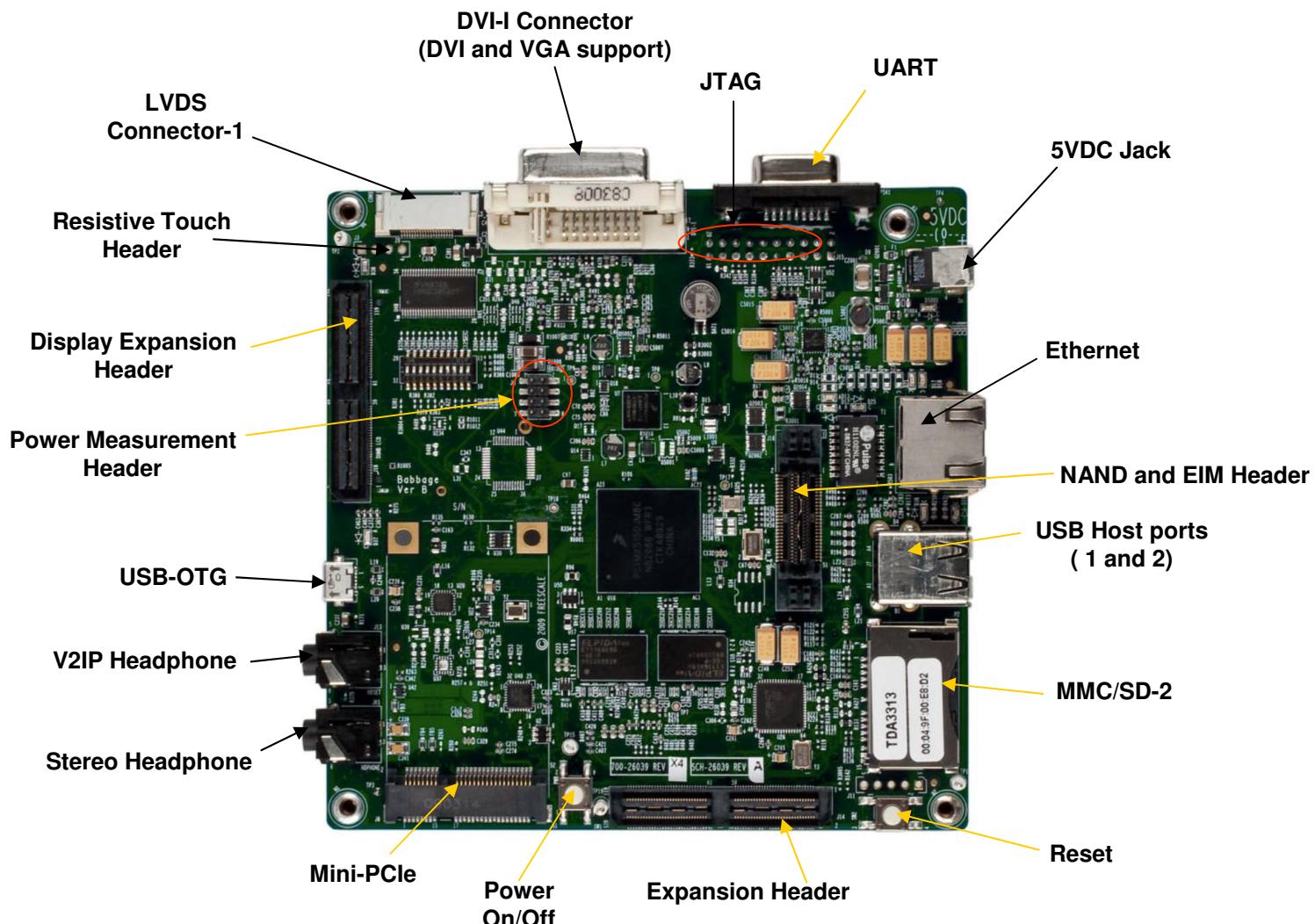
http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=i.MX515

The screenshot shows the i.MX51 Product Summary Page. On the left, there's a sidebar with sections for Features (CPU Complex, Multimedia, External Memory Interface), Documentation (IMX51CONINDFS, IMX51EVKKITFS, IMX51CEC), and Applications (Smartbooks, Mobile Internet Devices, PMPs, Gaming consoles, Secure Devices, Advanced HMI, High-end PDAs). The main content area has a header 'i.MX51 Product Summary Page - Microsoft Internet Explorer provided by Freescale'. Below the header are navigation buttons (back, forward, search) and a title bar 'i.MX51 Product Summary Page'. A red oval highlights the 'MCIMX51EVKJ: i.MX51 Evaluation Kit' link in the 'Current Updates & Releases' section.

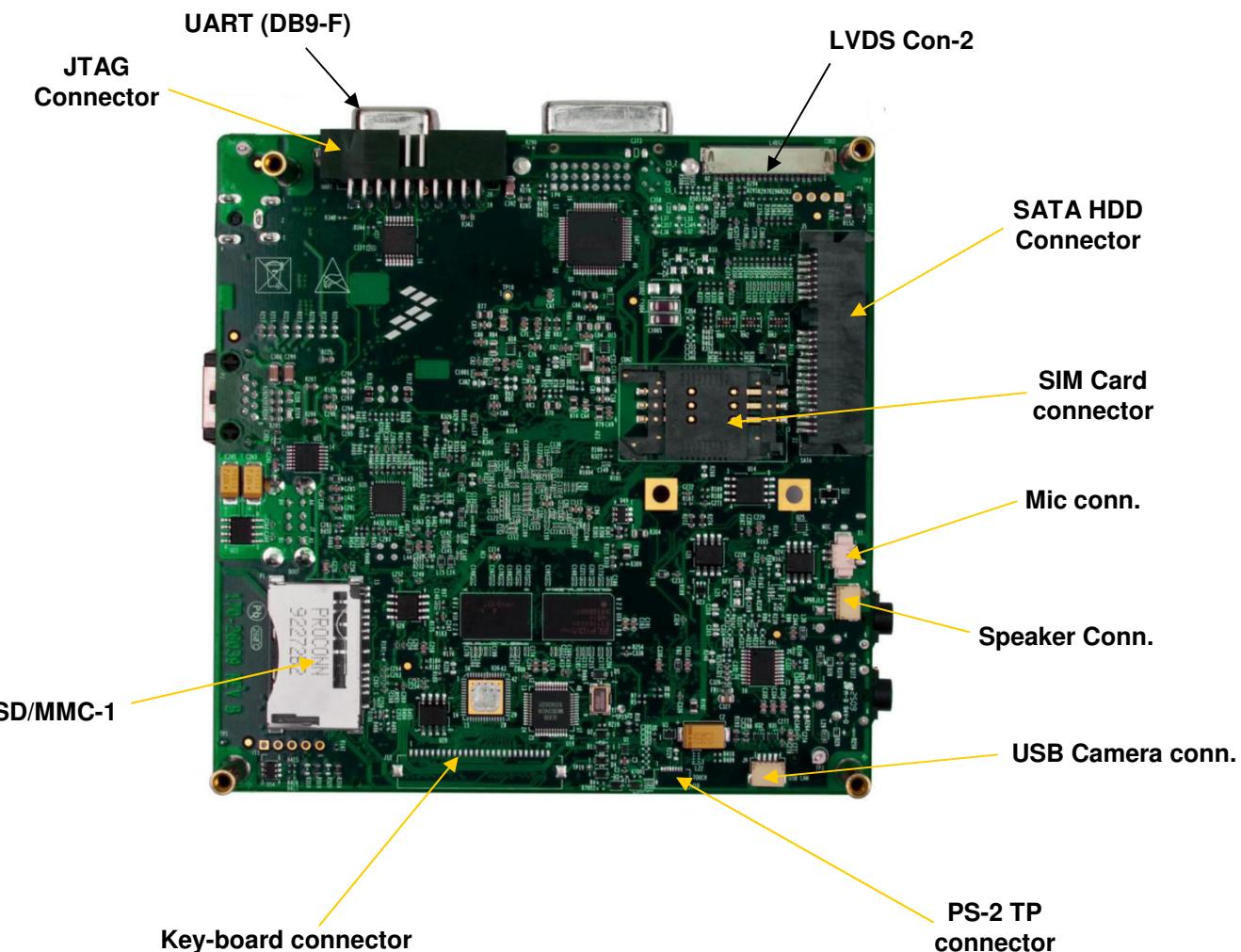
i.MX51EVK(Pls refer to BBG3.0 HW UG)



MCIMX51EVKJ: PCB Top

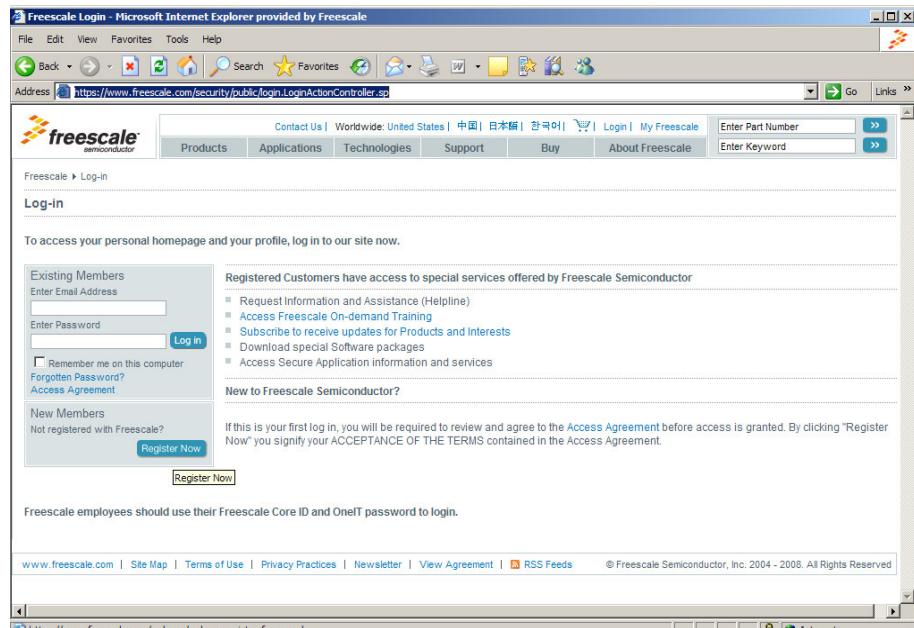


MCIMX51EVKJ: PCB Bottom



Freescale Member Registration for web resource download

1. For first time user, register to Freescale WEB site using this link and press “**Register Now**”



<https://www.freescale.com/security/public/login.LoginActionController.sp>

2. Input your email address and choose your login password and then press “**Next**” to continue:

The screenshot shows the 'Register New User' form. It has tabs at the top: 'Register info' (selected), 'Interests (Optional)', 'More Details', and 'Finish'. Below the tabs, there's a note about using email as the user ID and instructions for entering a password. The form contains three input fields with asterisks indicating required information: 'Email (Freescale ID)', 'Password', and 'Confirm Password'. There are also 'Cancel', 'Reset', and 'Next' buttons at the bottom.

► Linux BSP

Linux BSP on Freescale website

- http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=MCIMX51EVKJ&nodeld=0162468rH31143ZrDR633B&fbsp=1&tab=Design_Tools_Tab

The screenshot shows a web browser interface for the Freescale website. At the top, there is a navigation bar with tabs: Overview, Documentation, Downloads (which is circled in red), Buy / Specifications, and Training & Supp. Below the navigation bar, there is a 'Buy' button and a search bar with a 'Go' button and a 'Help' link. On the left, there is a sidebar titled 'Refine Your Results' with a 'Show:' dropdown set to 'Downloads - (12)'. This dropdown menu lists several categories: Development Tools (3), IDE - Debug, Compile and Build Tools (1), Simulation & Models (1), IBS (1), Printed Circuit Boards & Schematics (1), Run-time Software (9), Board Support Packages (7), and Codecs and other Algorithms (2). Below this, there are 'Sub Topics' for Device Type and Industry, with an 'Expand All' link. The main content area is titled 'Results 11' and contains a table of download items. The table has columns for 'ID and Description', 'Type', 'Format', and 'Size'. One item, 'IMX51_Linux_BSP', is highlighted with a red circle. The table data is as follows:

ID and Description	Type	Format	Size
IMX_ATK_TOOLKIT_R168 i.MX EVK 1.6 Advanced Tool Kit Standard 1.68: Flash tool for downloading, programing, dumping and...	Board Support Packages	exe	1
IMX51_LINUX_UNBUNTU_DEMO	Board Support Packages	gz	14
IMX51_LINUX_UNBUNTU_DEMO	Board Support Packages	zip	3
IMX51_SDK16_LINUX_BSP_VALIDATION	Board Support Packages	zip	3
IMX51_SDK16_LINUX_BSP_Validation_Tests	Board Support Packages	gz	2
IMX51_SDK16_LINUX_DEMO	Board Support Packages	gz	2
Linux 2.6.28 Binary Demo Files Release 1.6	Board Support Packages	gz	51
IMX51_SDK16_LINUX_BSP Linux 2.6.28 Source Code Files Release 1.6	Board Support Packages	zip	5
IMX51_SDK16_WINCE6_DEMO	Board Support Packages	zip	5
Windows Embedded CE 6.0 Binary Demo Files Release 1.6	Board Support Packages	zip	5

Ubuntu Image on Freescale website

- http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=MCIMX51EVKJ&fpst=1&tab=Design_Tools_Tab

The screenshot shows a product page for the MCIMX51EVKJ. At the top, there are tabs for Overview, Documentation, Downloads (which is highlighted with a red circle), and Buy / Specifications. Below the tabs is a search bar with a 'Go' button and a 'Help' link. To the left, a sidebar titled 'Refine Your Results' shows a tree view of categories under 'Downloads': Development Tools (IDE, Simulation & Models, Printed Circuit Boards & Schematics), Run-time Software (Board Support Packages, Codecs and other Algorithms), and Sub Topics (Device Type, Industry). The main area displays 'Results 11' for 'ID and Description'. The first result is 'IMX_ATK_TOOLKIT_R168'. The second result, 'IMX51_LINUX_UBUNTU_DEMO', is highlighted with a red circle. Other results listed include 'IMX51_LINUX_UBUNTU_DEMO', 'IMX51_SDK10_LINUX_BSP_VALIDATION', 'IMX51_SDK16_LINUX_BSP_Validation_Tests', 'IMX51_SDK16_LINUX_DEMO', 'Linux 2.6.28 Binary Demo Files Release 1.6', 'IMX51_SDK16_LINUX_BSP', 'Linux 2.6.28 Source Code Files Release 1.6', 'IMX51_SDK16_WINCE6_DEMO', and 'Windows Embedded CE 6.0 Binary Demo Files Release 1.6'. The right side of the results table shows columns for Type (Board S, Packag) and Description.

ID and Description	Type	Description
IMX_ATK_TOOLKIT_R168	Board S	i.MX EVK 1.6 Advanced Tool Kit Standard 1.68: Flash tool for downloading, programing, dumping and...
IMX51_LINUX_UBUNTU_DEMO	Packag	
IMX51_LINUX_UBUNTU_DEMO	Board S	
IMX51_SDK10_LINUX_BSP_VALIDATION	Board S	
IMX51_SDK16_LINUX_BSP_Validation_Tests	Packag	
IMX51_SDK16_LINUX_DEMO	Board S	
Linux 2.6.28 Binary Demo Files Release 1.6	Packag	
IMX51_SDK16_LINUX_BSP	Board S	
Linux 2.6.28 Source Code Files Release 1.6	Packag	
IMX51_SDK16_WINCE6_DEMO	Board S	
Windows Embedded CE 6.0 Binary Demo Files Release 1.6	Packag	

Linux BSP document on Freescale website

- http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=MCIMX51EVKJ&fpsp=1&tab=Documentation_Tab

Freescale > i.MX Applications Processors > i.MX51 Processors > MCIMX51EVKJ

i.MX51 Evaluation Kit

Overview Documentation Downloads Buy / Specifications Training

Buy |

Refine Your Results

Show: Documentation - (10)

- Reference Manuals - (1)
- Users Guides - (4)
- Fact Sheets - (1)
- Quick Reference Guides - (2)
- Supporting Information - (2)

Sub Topics

- + Device Type
- + Special Topics

Expand All

Search Go Help

Results 10

Featured Documentation

ID and Description	Type	Format	Size K
IMX51_IPU_LIB_UG i.MX51 IPU V3 Library User's Guide	Reference Manuals	pdf	212
R168_ATK_UG i.MX EVK 1.6 Advanced Toolkit Standard 1.68 User's Guide: Installation, setup, operation	Users Guides	pdf	459
CE_6_0_FUNDAMENTALS_EBOOK Fundamentals eBook	Users Guides	pdf	9699
IMX51_EVK16_IIC	Users Guides	pdf	0.67

Linux BSP release packages

Source package (L2.6.28_4.5.1_SDK_Aug2009_source.tar.gz)

- LTIB
- Boot loader sources (redboot) and toolchain
- Kernel and driver sources (kernel.org code + FSL patches)
- User space packages
- Compiler/Linker and friends (GNU ARM, currently 4.1.2 eABI/VFP)

Documentation (L2.6.28_4.5.1_SDK_Aug2009_docs.tar.gz)

- BSP release note, user guide and reference manual
- Resolved and Unresolved Defects status
- Feature matrix for each supported chip/HW

Binary Image package

(L2.6.28_4.5.1_SDK_Aug2009_FormallImage_MX51.tar.gz)

- Kernel binary (zImage) for each supported chip/HW
- Root file system image for each supported chip/HW
- Boot loader binary image for each supported chip/HW

- ▶ All Freescale kernel code is open source
 - No Freescale proprietary code
 - All Freescale code is licensed under the GPL
- ▶ Some Freescale user space code is proprietary
 - The Multimedia codecs
 - The graphical user interface (MESH)
⇒ **binary only in release**
- ▶ The rest of the Freescale user's space code is open source
 - Gstreamer plugins, licensed under LGPL
- ▶ Some 3rd party code can not be released
 - Example: CSR BT/WiFi driver
⇒ **binary only in release**

VMWARE Player install

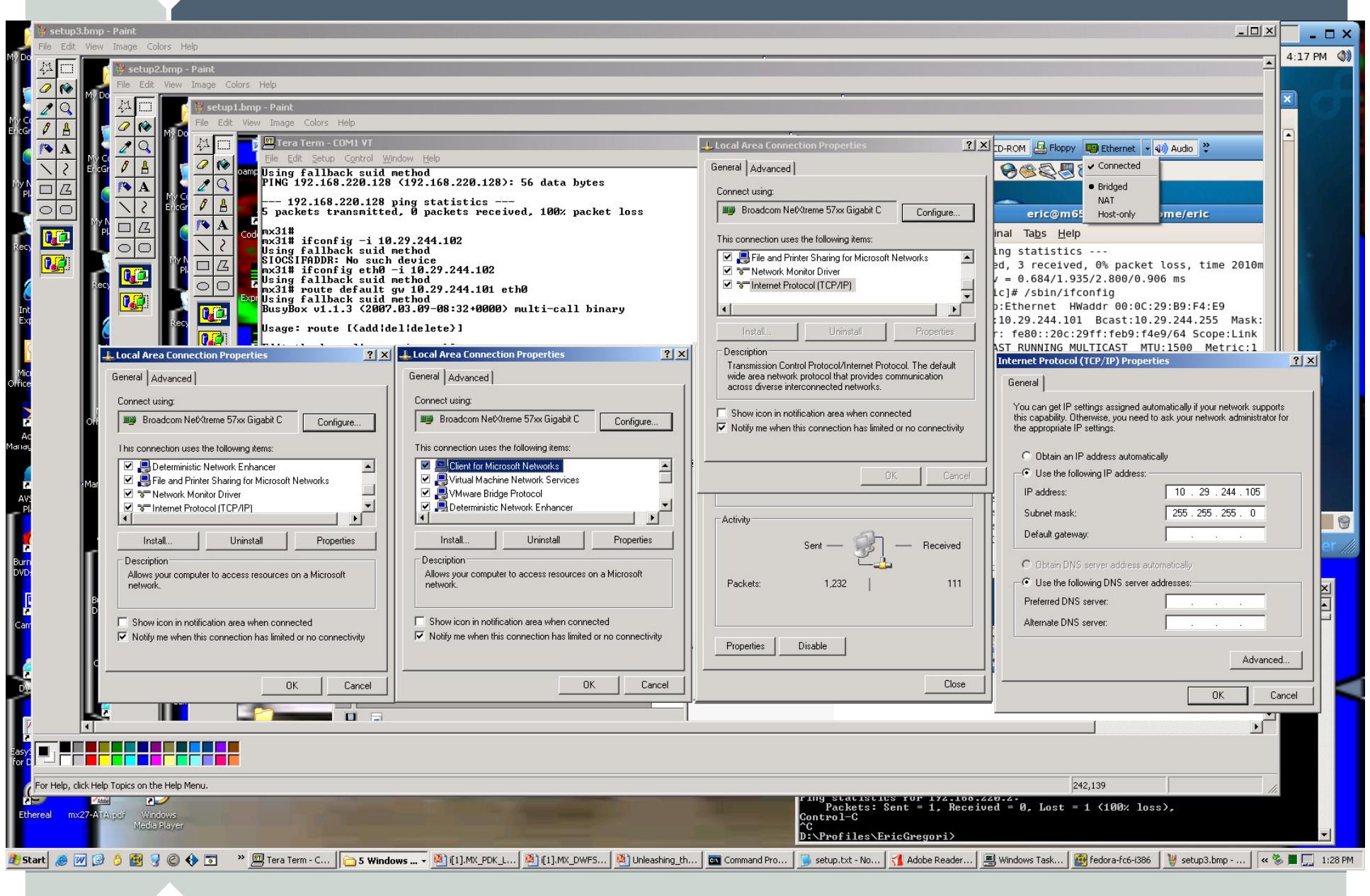
- ▶ VMWARE is virtual machines, which can run multiple OS on one PC
- ▶ Install VMWARE on your PC(VMware-player-2.5.2-156735.exe)
- ▶ username / password for ubuntu image:william/william

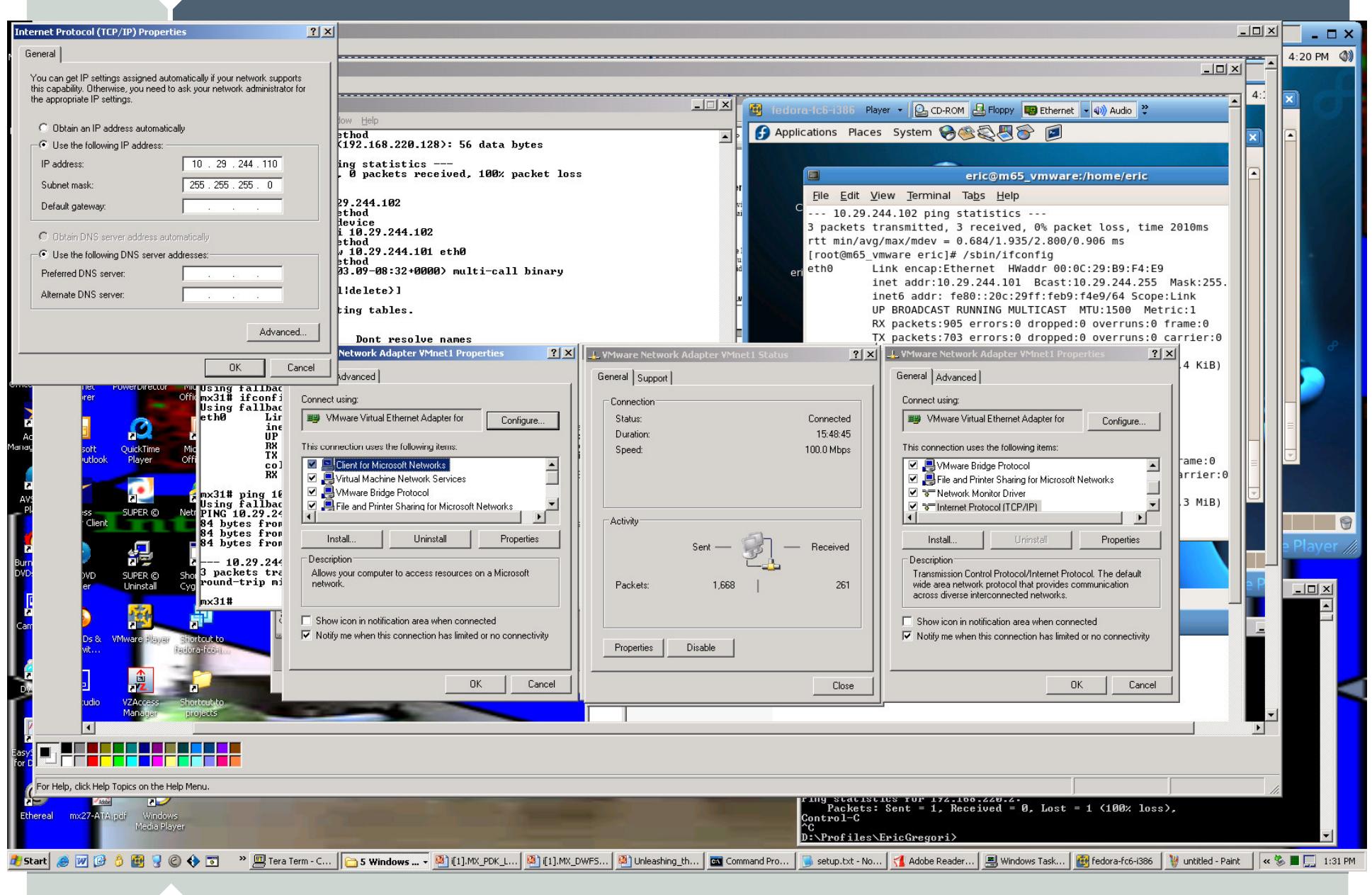
Open ubuntu using VMWARE Player

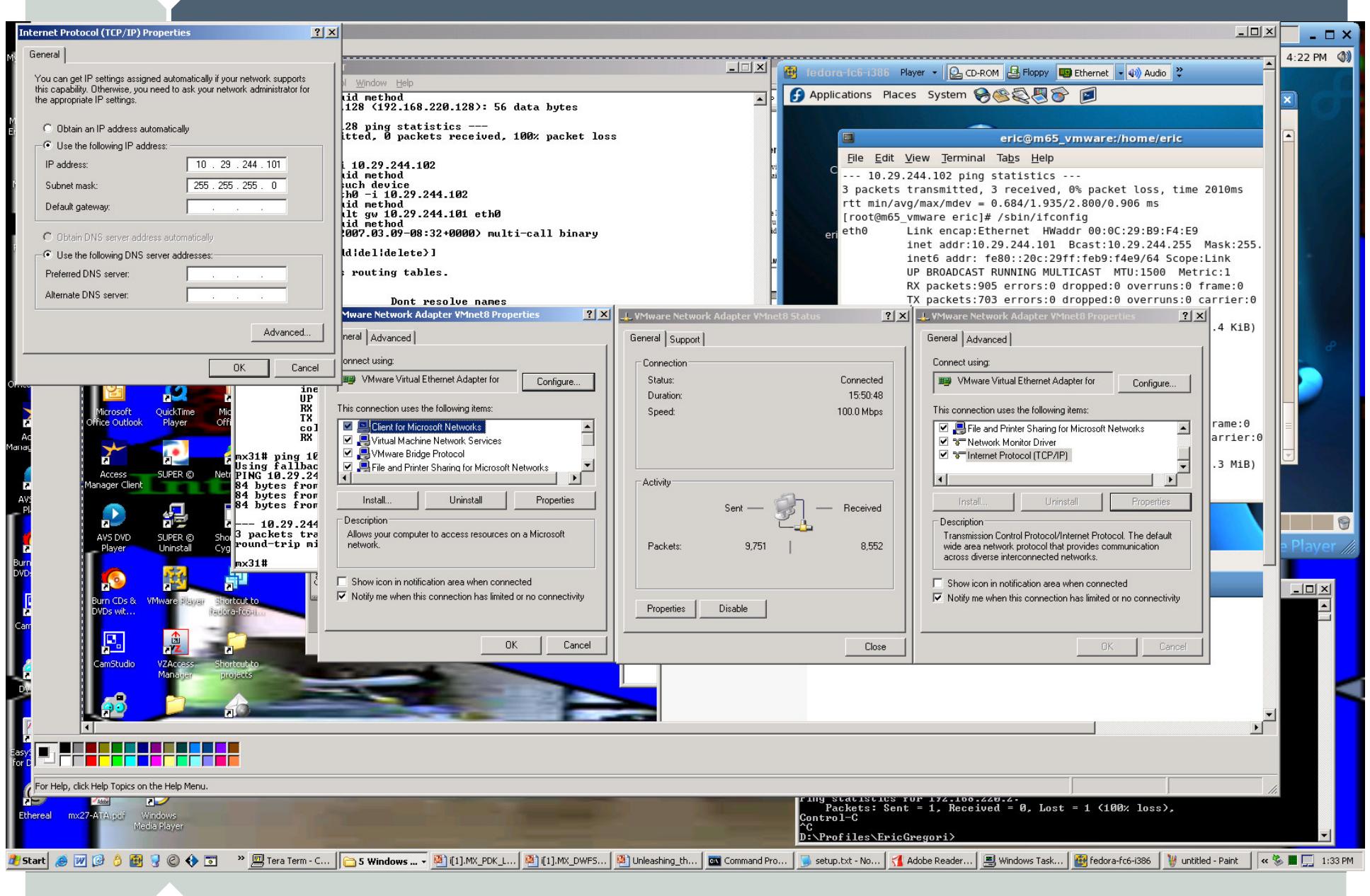


Open ubuntu image using VMWARE Player (Cont.)









- ▶ User name – william
- ▶ Password - william
- ▶ Username – root
- ▶ Password- Freescale123
 - # ifconfig eth2 10.29.244.101
 - # ifconfig eth2 netmask 255.255.255.0
 - # ifconfig eth2 broadcast 10.29.244.255
 - #/etc/init.d/xinetd restart
 - #/etc/init.d/nfs-common restart

LTIB instruction

- ▶ Stands for Linux Target Image Builder
- ▶ is an open source tool run by Freescale, under the GNU General Public License V2 or later (GPL).
- ▶ is made up of PERL scripts
- ▶ a number of embedded target platforms including PowerPC, ARM, Coldfire.
- ▶ builds flashable root file system images (jffs2 for MX51)
- ▶ has been successfully run on Fedora, Ubuntu and Suse.

LTIB Instruction (Cont.)

► More information on LTIB:

- Main web site: <http://www.bitshrine.org/>
- Freescale Internal: <http://twiki.freescale.net/bin/view/DEVTECH/LtibHome>
- Project web site: <http://savannah.nongnu.org/projects/lreib>
- Documentation provided with each release

Configure Host Linux Environment

Setup a Ubuntu 9.04 Linux host for LTIB

- ▶ NFS

1. sudo apt-get install nfs-kernel-server nfs-common portmap
2. sudo vi /etc/exports
3. sudo /etc/init.d/nfs-kernel-server restart
4. sudo exportfs

- ▶ TFTP

- ▶ Samba(File sharing)
- ▶ K-scope (Code editing in Linux)
- ▶ Meld (file/directory comparison tool)

sudo apt-get install meld

- ▶ Gparted (GNOME partition editor)

sudo apt-get install gparted

Setup a Ubuntu 9.04 Linux host for LTIB(Cont.)

► LTIB can work under Ubuntu 9.04 with following packages installed. (`sudo apt-get install ...`)

- bison
- g++
- gettext
- libbeecrypt6
- libglib2.0-dev
- libncurses5-dev
- librpm4.4
- m4
- patch
- rpm
- tcl
- tcl8.4
- zlib1g-dev

To install and compile Linux BSP

1. Create a folder

```
mkdir test
```

- 2 Copy source into test folder

```
cd test
```

```
cp ..\L2.6.28_4.3.0_ER_Jun2009_source.tar.gz .
```

3. Enter the following commands:

```
tar -zxvf L2.6.28_4.3.0_ER_Jun2009_source.tar.gz
```

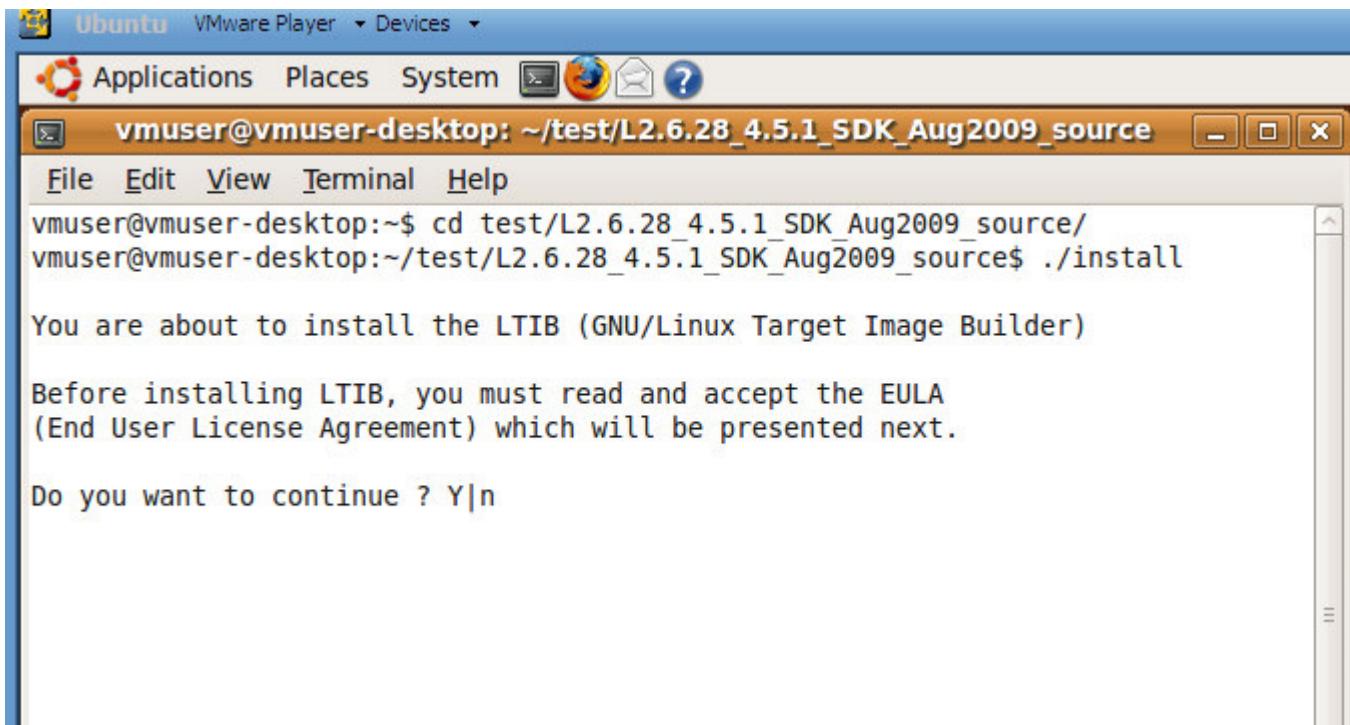
```
./ L2.6.28_4.3.0_ER_Jun2009_source/install
```

You will be prompted to continue.

4. Type “Y”.

The EULA is displayed.

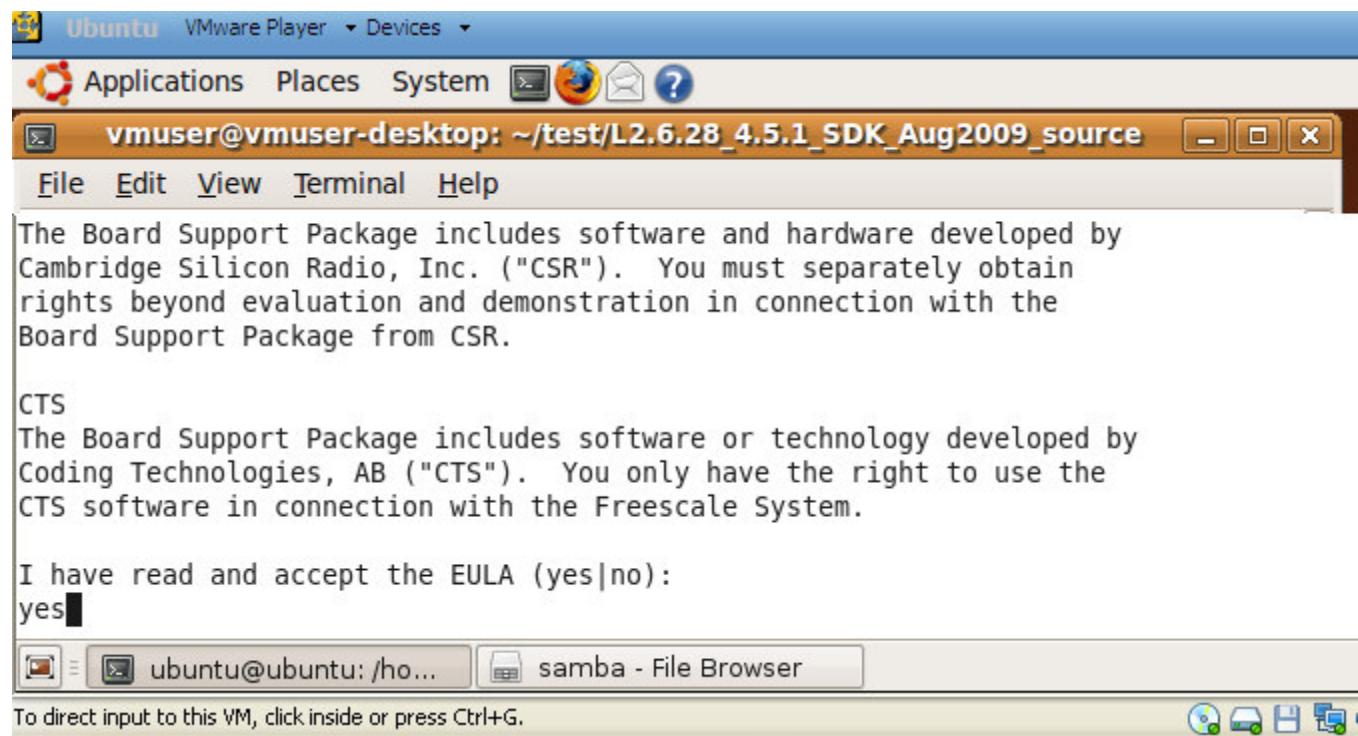
To install and compile Linux BSP(cont.)



To install and compile Linux BSP

3. Press the space bar to scroll through the EULA(End User License Agreement).
You will be asked if you have read and accept the EULA.
4. Type yes.
You will be prompted to supply a pathname for the installation.

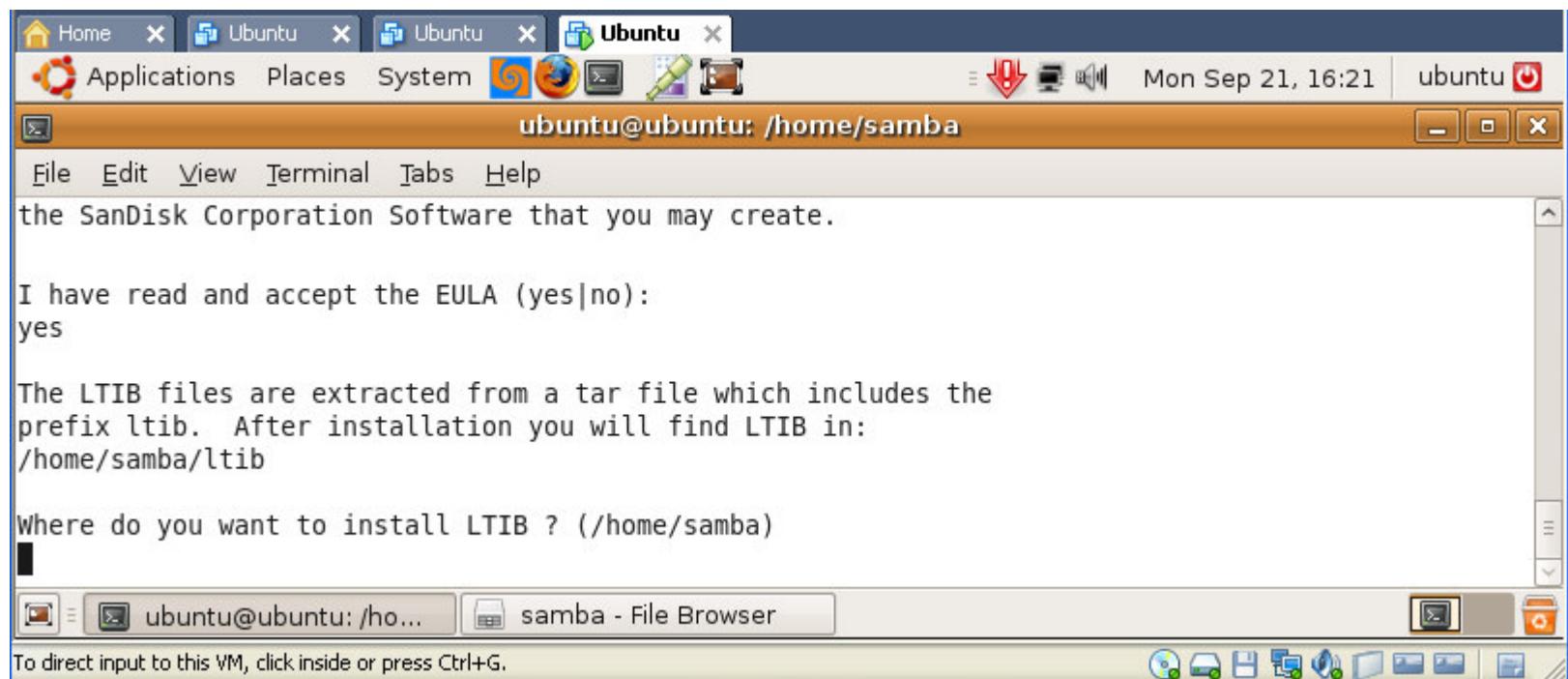
To install and compile Linux BSP(cont.)



To install and compile Linux BSP(Cont.)

5. Specify the pathname.

The system will create an LTIB folder in the specified location and install the packages needed for the build.



A screenshot of an Ubuntu desktop environment showing a terminal window. The terminal window title is "ubuntu@ubuntu: /home/samba". The terminal content shows the following interaction:

```
the SanDisk Corporation Software that you may create.

I have read and accept the EULA (yes|no):
yes

The LTIB files are extracted from a tar file which includes the
prefix ltib. After installation you will find LTIB in:
/home/samba/ltib

Where do you want to install LTIB ? (/home/samba)
```

The terminal window is part of a desktop interface with other windows visible in the background, including a file browser titled "samba - File Browser".

To install and compile Linux BSP

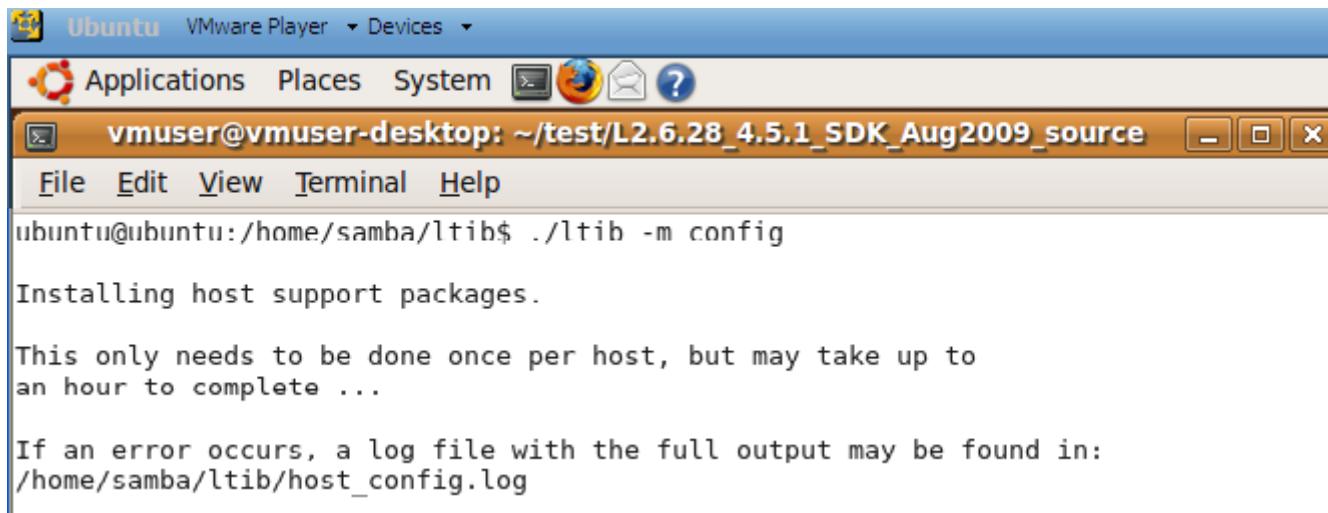
5. Enter the following commands:

```
cd <your ltib install path>/ltib
```

```
unset KBUILD_OUTPUT
```

6. Run the following command, not as root:

```
./ltib -m config
```



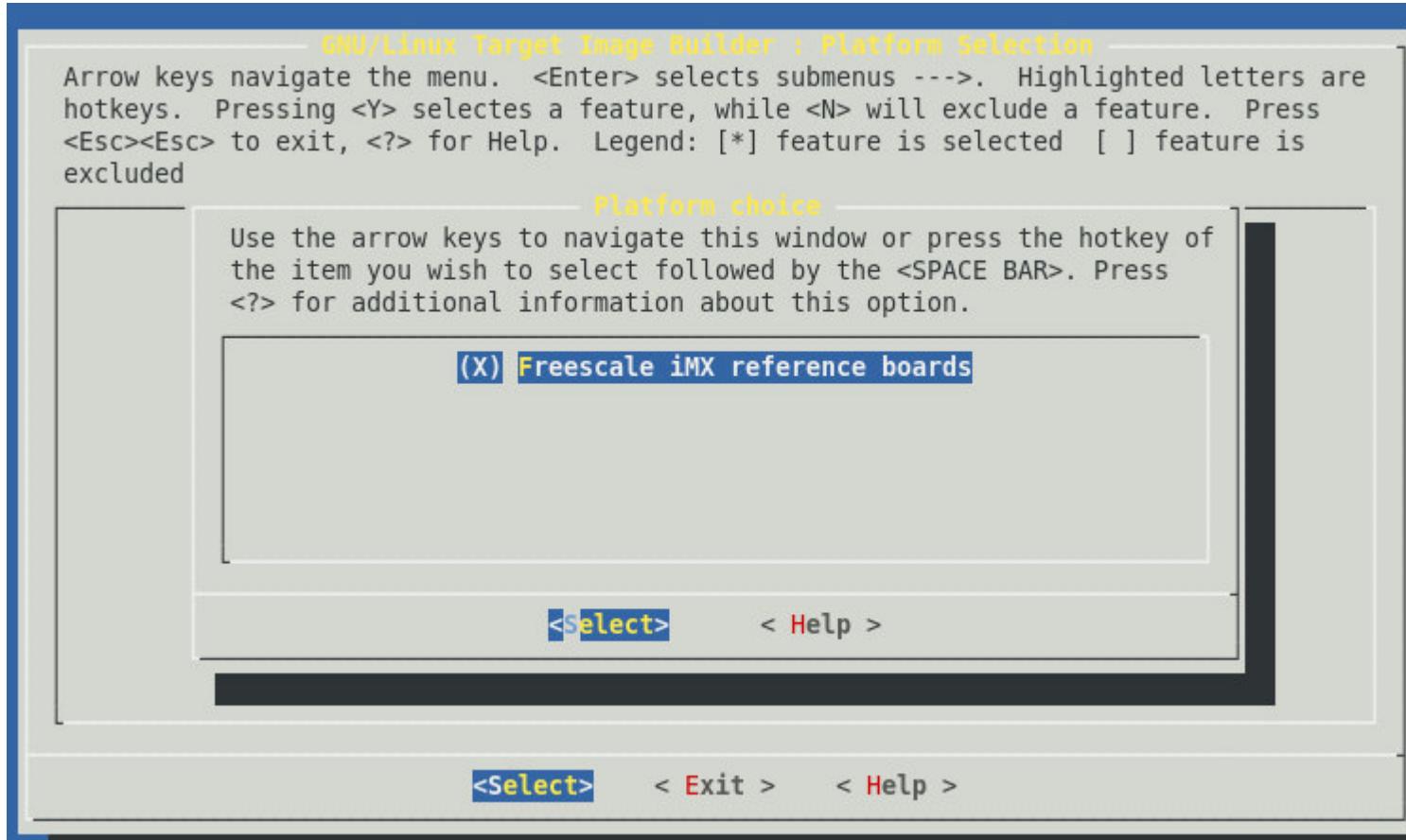
The screenshot shows a terminal window titled "vmuser@vmuser-desktop: ~/test/L2.6.28_4.5.1_SDK_Aug2009_source". The window contains the following text:

```
ubuntu@ubuntu:/home/samba/ltib$ ./ltib -m config
Installing host support packages.
This only needs to be done once per host, but may take up to
an hour to complete ...
If an error occurs, a log file with the full output may be found in:
/home/samba/ltib/host_config.log
```

To install and compile Linux BSP (Cont.)

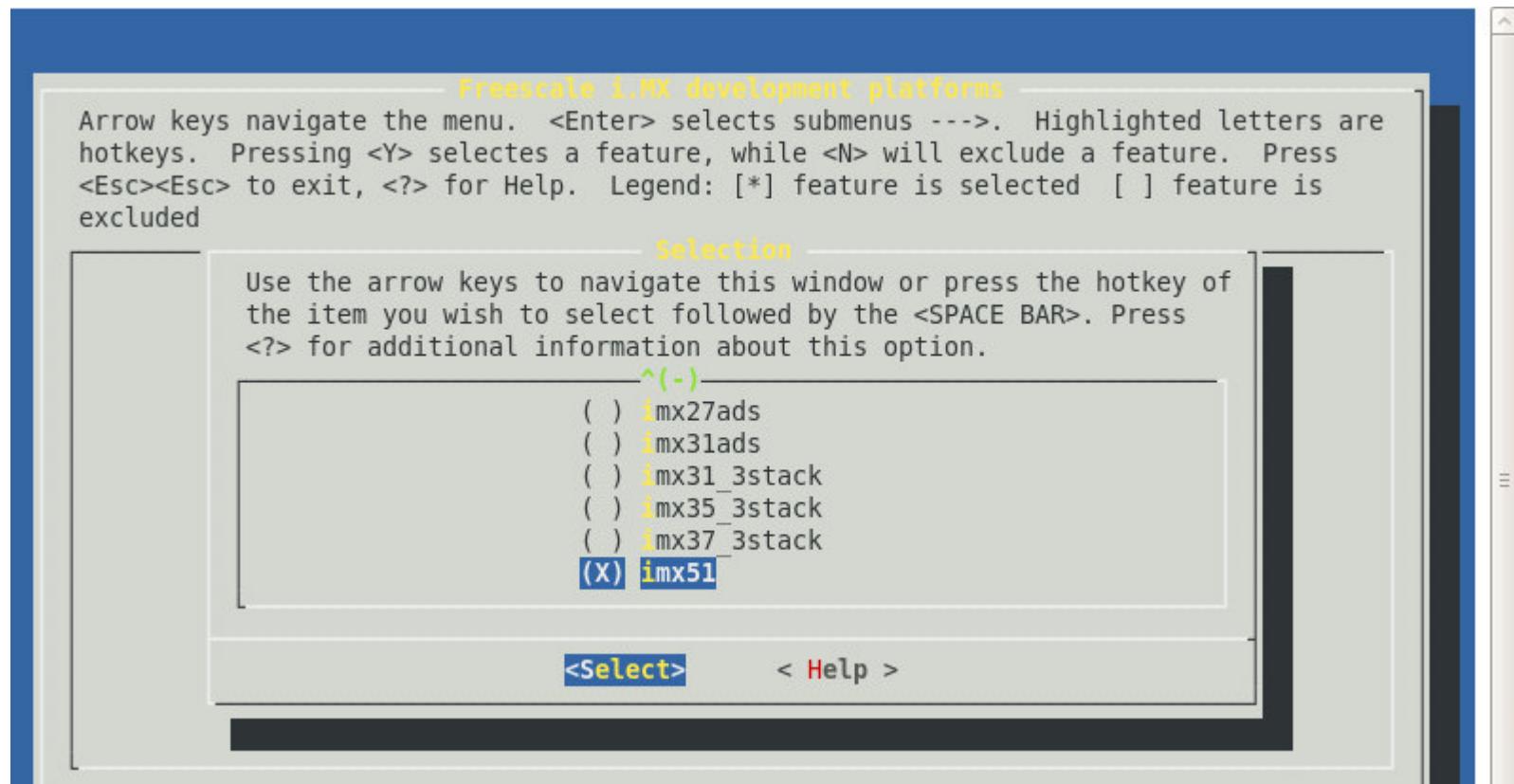
8. Press <Enter> and select “Freescale iMX reference boards” as the platform choice. Exit saving changes.
Another menu will pop up to select the board.

To install and compile Linux BSP (Cont.)



To install and compile Linux BSP(Cont.)

8. Use the arrow keys to select <Platform type>.



To install and compile Linux BSP(Cont.)

- ▶ Use the arrow keys to select <**Packages Profile**>. The default is a minimal rootfs.
After saving changes, another menu will pop up to change config options for the selected board.
Make any desired changes, and then exit, saving the changes.

- ▶ To start a build, run:
`./ltib`
LTIB will build the kernel, modules, and a rootfs.

To install and compile Linux BSP(Cont.)

```
ubuntu@ubuntu: /home/samba/ltsb There are 124 updates available
File Edit View Terminal Tabs Help

Processing: modeps
=====
Processing deployment operations
=====
making filesystem image file
staging directory is /home/samba/ltsb/rootfs.tmp
removing the boot directory and files
removing man files and directories
removing info files
removing /usr/share/locale directory
removing static libraries
removing target rpm database
stripping binaries and libraries

Filesystem stats, including padding:

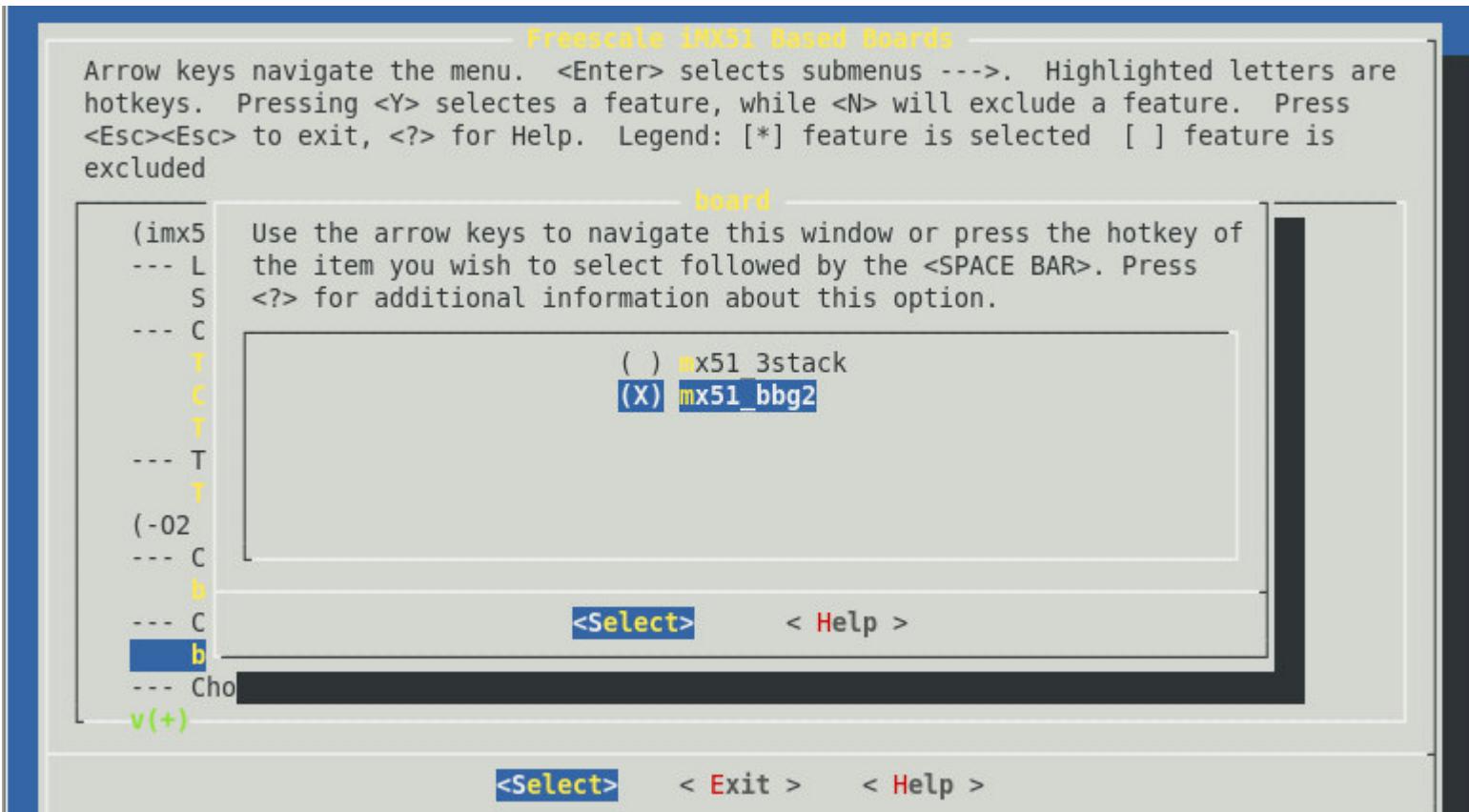
    Total size          = 48876k
    Total number of files = 3303

Started: Thu Sep 24 21:46:48 2009
Ended:   Thu Sep 24 21:50:22 2009
Elapsed: 214 seconds

Build Succeeded
```

To install and compile Linux BSP(Cont.)

► Uboot configuration

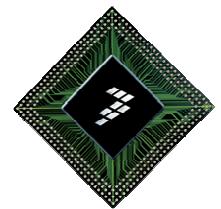


LTIB Tips

- ▶ LTIB help
`./ltib --help`
 - ▶ To switch to a different board, enter the following command
`./ltib --selectype`
 - ▶ To select an alternate set of userspace packages. (Under ltib/config/profile)
`./ltib --profile profile name`
 - ▶ Build the package only
`./ltib -p package name`
-
- ▶ *IP Address: 10.29.244.102 (target)*
 - ▶ *Netmask.255.255.255.0*
 - ▶ *Gate way: 10.29.244.101*
 - ▶ *Host IP address: 10.29.244.101 (host)*



Embedded Linux® System Components

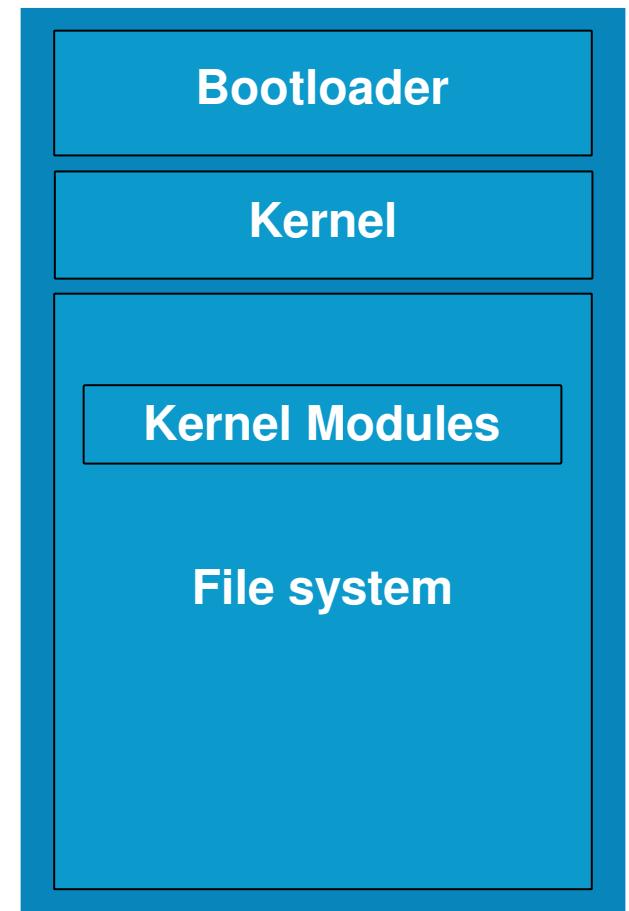


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Basic Embedded Linux System

- Bootloader
- Kernel
- File System :
 - Kernel Modules
 - Shared Libraries
 - Applications
 - Miscellaneous system files

Target Board

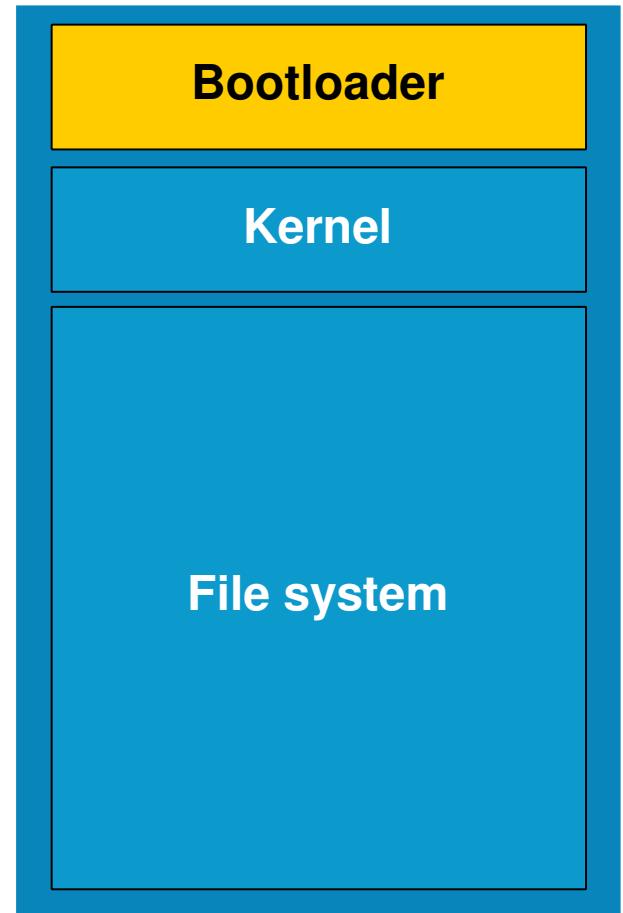


Target Memory

BOOTLOADERS

- Used to initialize the board
- Provides mechanism for initial interaction with board
- Provides mechanism to boot kernel
- Configured and built for specific board
- Common bootloaders
 - ColdFire → Colilo, u-boot, dBUG
 - Power Architecture™ → u-boot
 - ARM → blob, redboot, u-boot

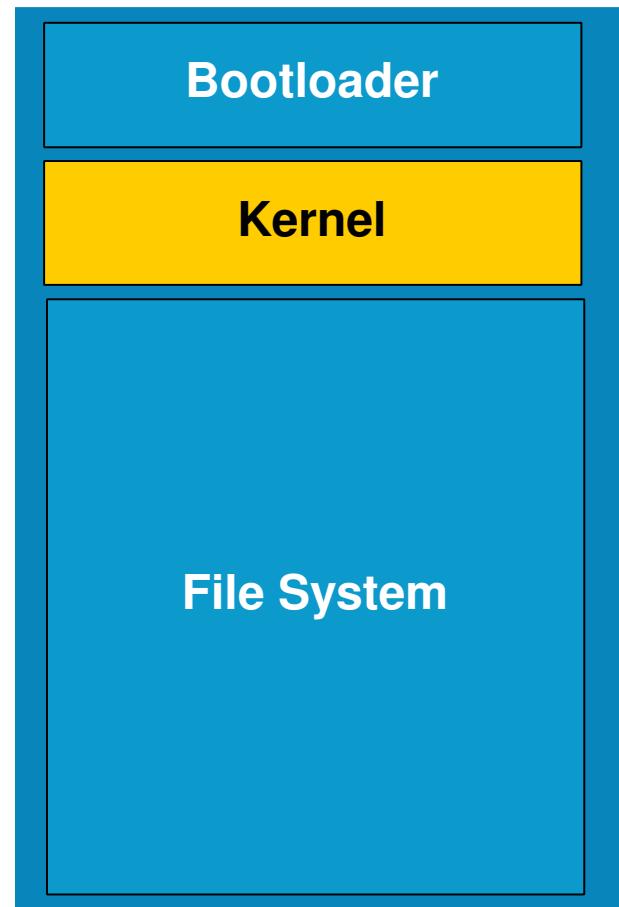
Target Board



KERNEL

- Continued initialization of the board
- Provides mechanism to interact with devices (drivers)
- Provides underlying protocol support (TCP/IP) and OS
- The Linux kernel configuration allows many features to be selected and configured

Target Board



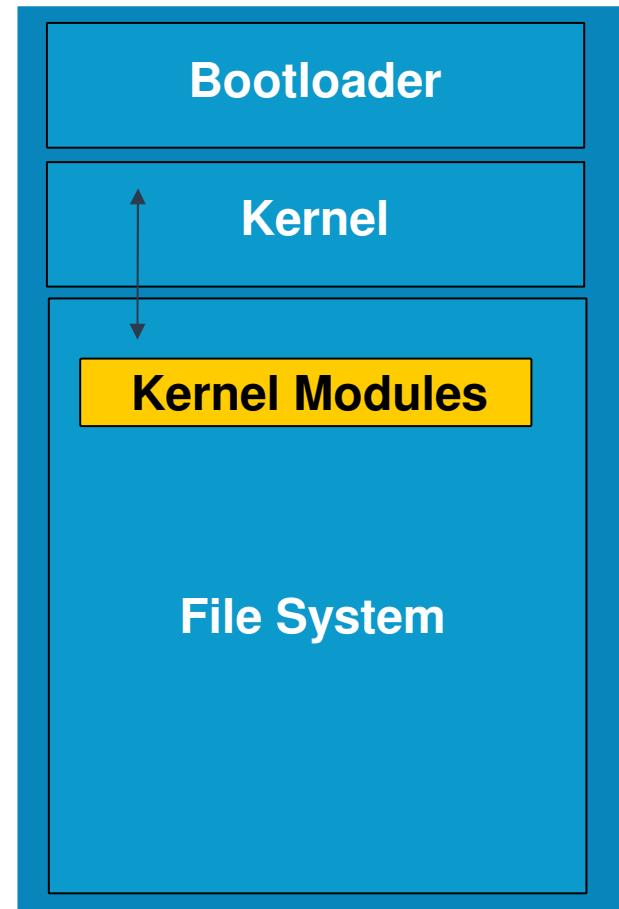
Basic Embedded Linux® System

Kernel Modules

KERNEL MODULES

- Implement device drivers
- Provide additional functionality to kernel
- Reside in the file system and can be loaded and unloaded from the kernel

Target Board

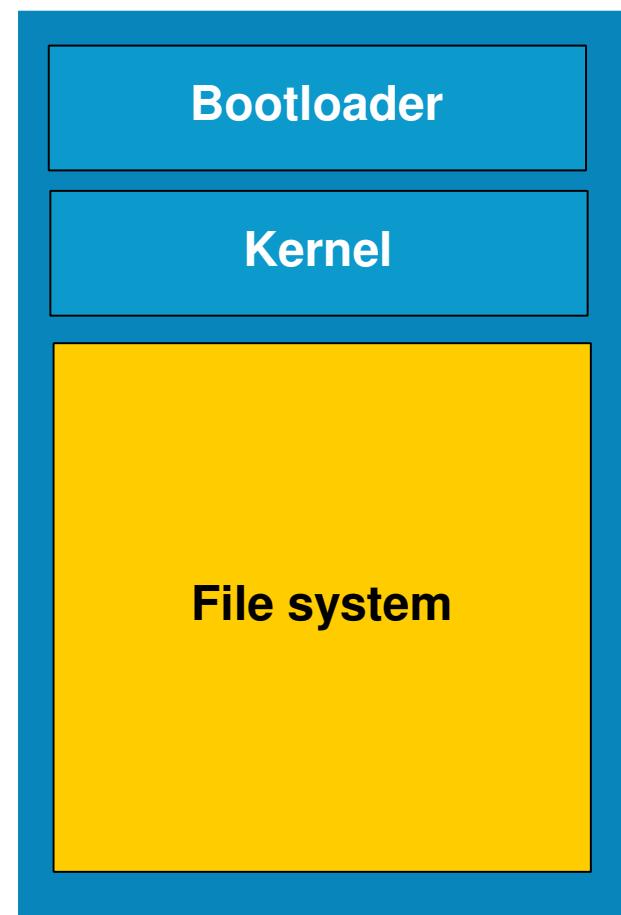


Basic Embedded Linux® System File Systems

FILE SYSTEM

- Protected by Memory Management Unit (MMU) (user land)
- Applications live here
- Common Embedded File System Types
 - EXT2/3
 - Journaling Flash File System version 2 (JFFS2)
 - CRAMFS
 - YAFFS

Target Board

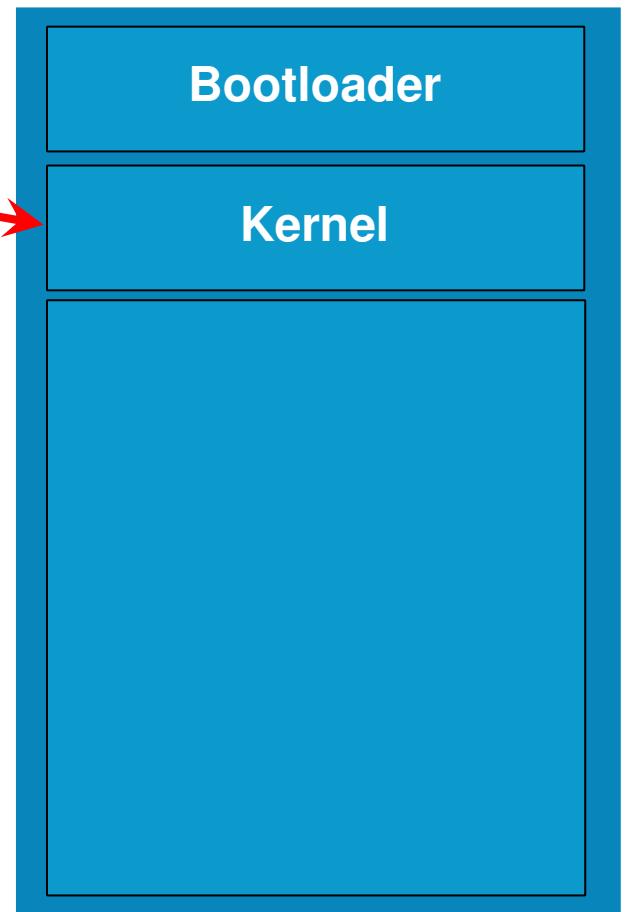


Basic Embedded Linux® System File Systems - NFS (Network File System)

Linux Host PC

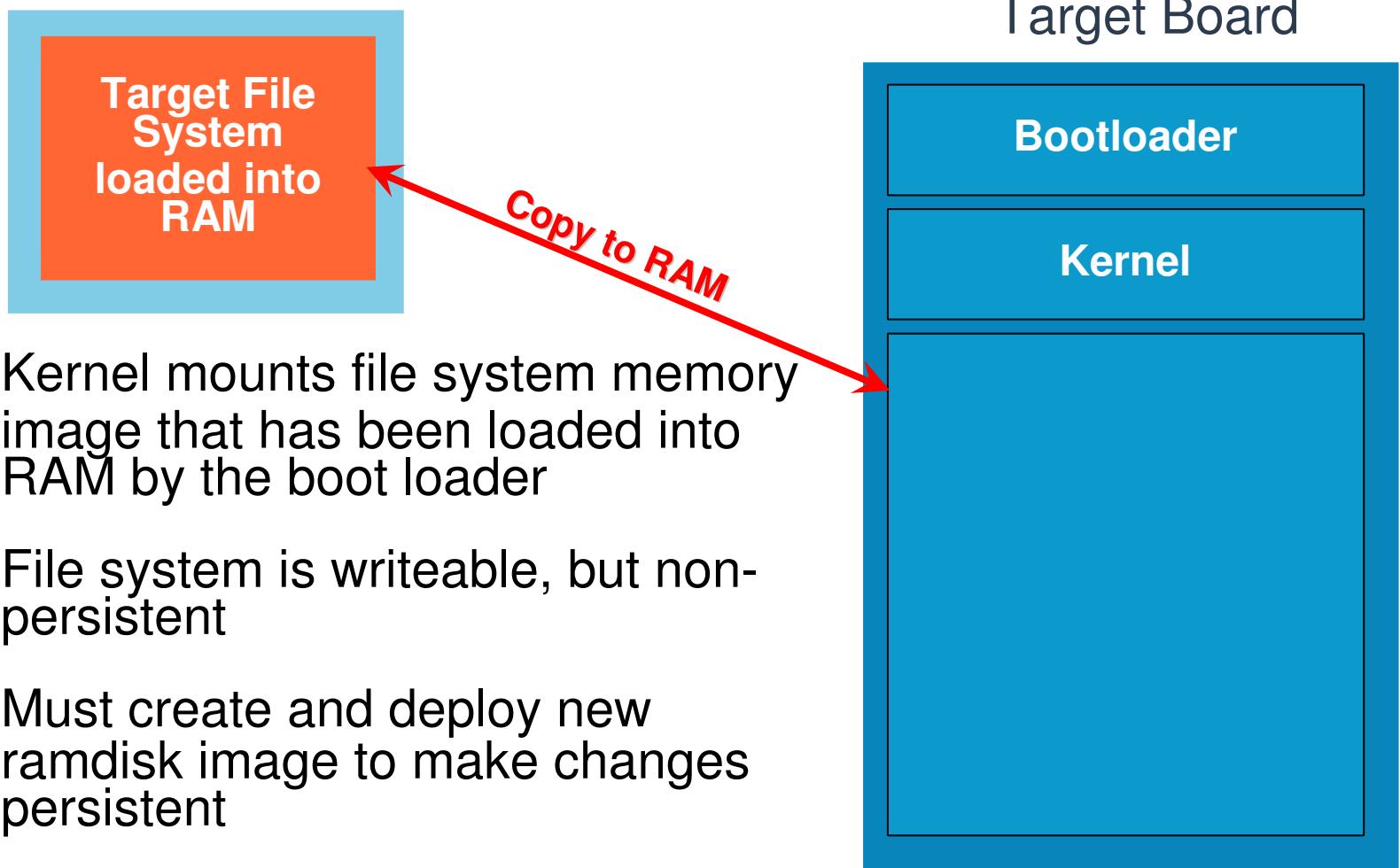


Target Board



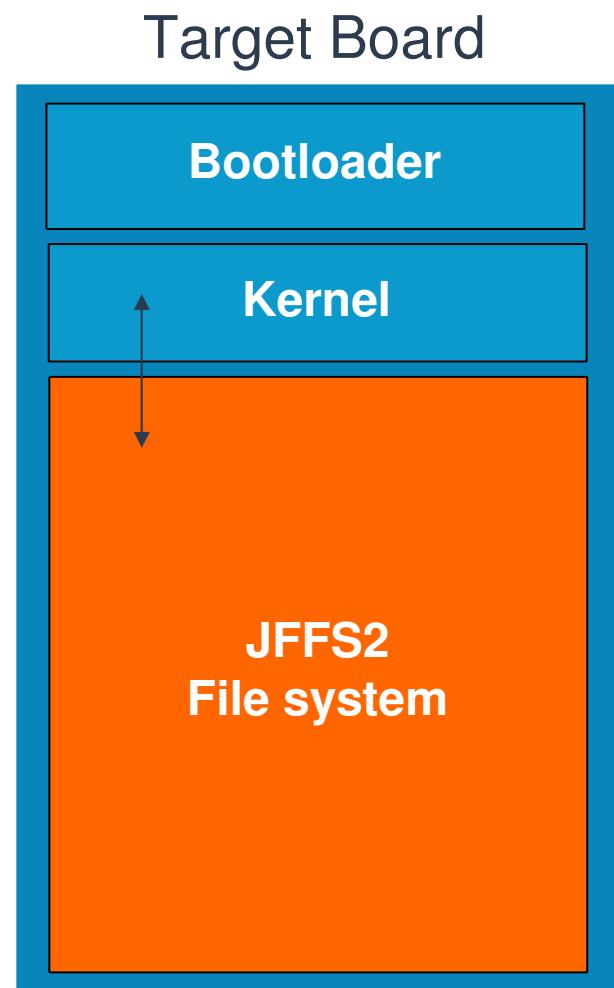
- Kernel mounts the root file system over the network
- The file system resides on host PC
- Files copied into the exported file system become instantaneously available on the target
- For development only, not for product

Basic Embedded Linux® System File Systems - Ramdisk File System



Basic Embedded Linux® System File Systems JFFS2 - Journaling Flash File System 2

- The file system resides on target board flash
- Kernel mounts the root file system from a specified partition of flash
- File system is writeable
- File system is persistent (changes written to flash)
- JFFS2 driver handles interaction with flash

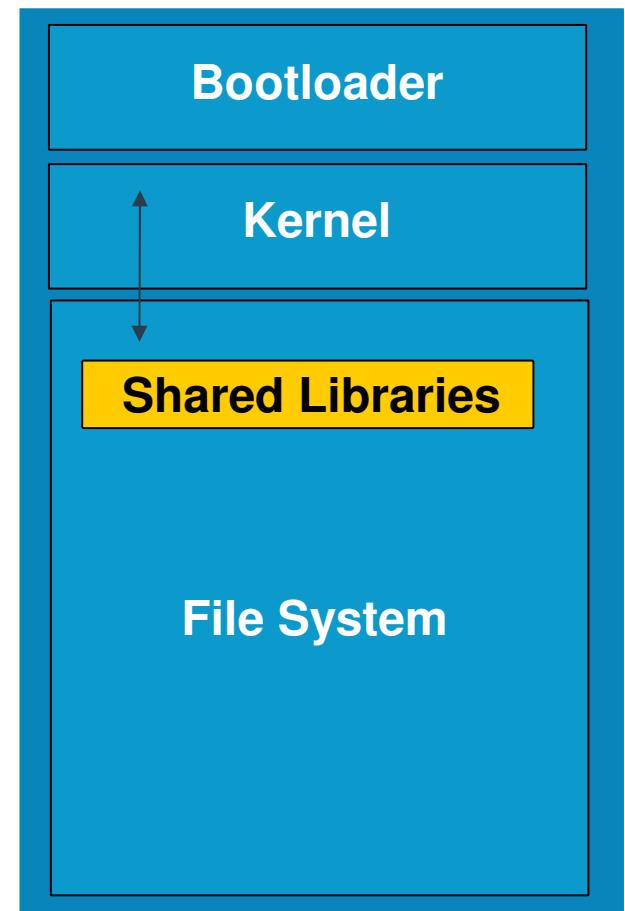


Basic Embedded Linux® System Shared Libraries

GLIBC - UCLIBC

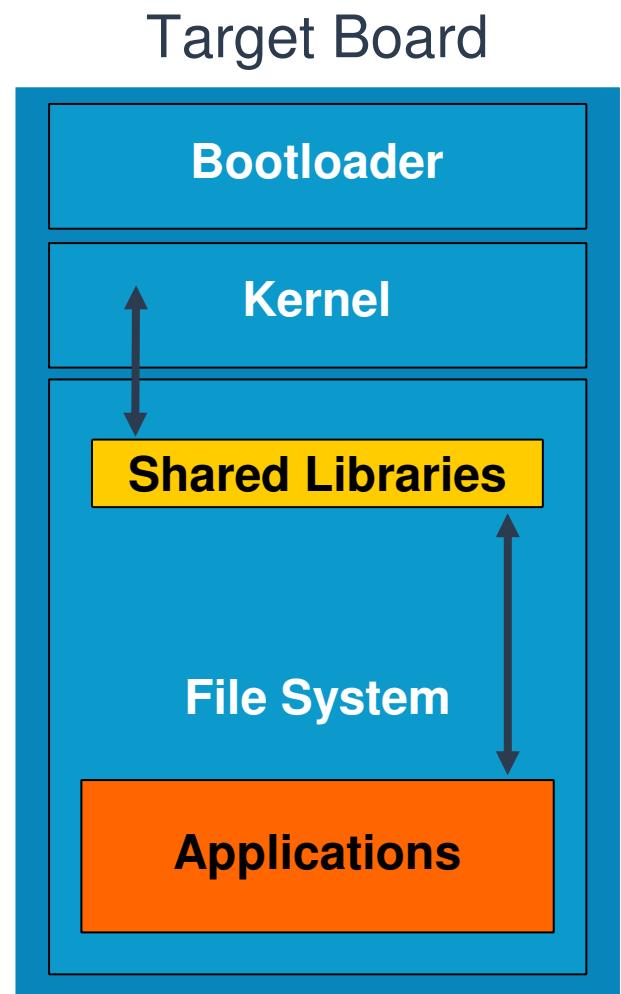
- Provides mechanism for user land to interact with the kernel
- Resides in the file system
- Can be used by multiple applications (re-entrant)

Target Board



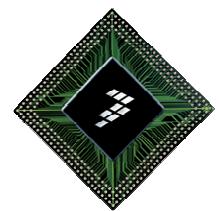
Basic Embedded Linux® System Applications

- User commands (ping, ls, cd, cat)
- Provides functionality to the system
- Resides in the file system.
- Accesses kernel functionality via the shared libraries.
- Cannot access kernel space (protected memory) directly.
- Must be compiled against the same version of shared library that is located on the embedded system





Linux® System Boot Process



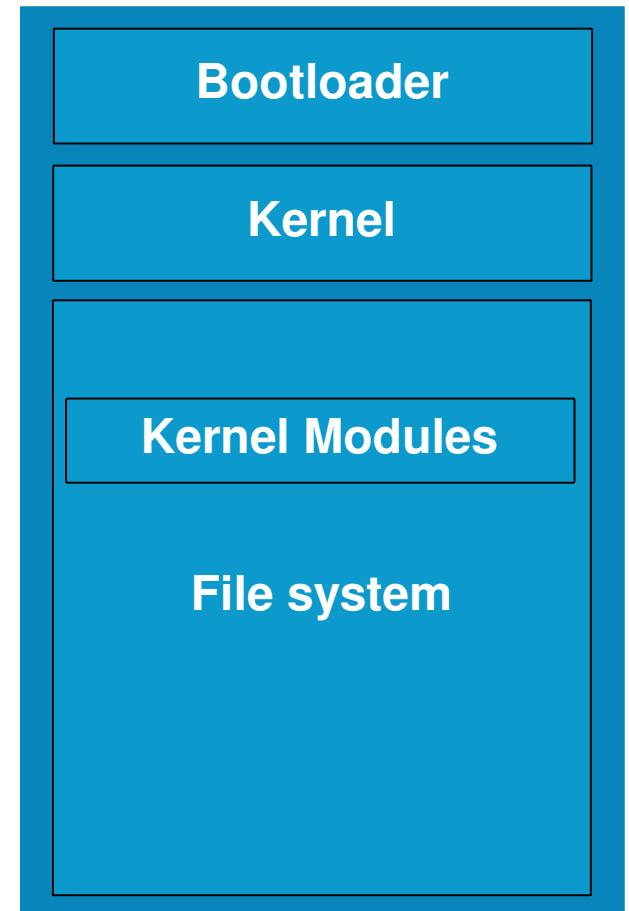
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Embedded Linux® System Boot Process

Linux System Boot Process

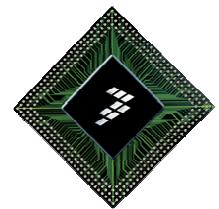
- Bootloader
 - Initializes board
 - Loads and starts kernel
- Kernel
 - Continued board initialization
 - Mounts file system
 - Starts an application called “init”
- File System
 - init runs a set of scripts that:
 - setup/configure the Linux system
 - starts a shell
 - gives a login prompt
 - User logs into the system

Target Board





LTIB Kernel and RFS Configuration



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- ▶ Freescale *GNU/Linux Target Image Builder* is a tool created by Freescale, that is used to build Linux target images, composed of a set of packages
 - A mechanism to deliver Linux board support packages (BSP)
 - A wrapper around tool chains and standard Linux commands (**cp**, **make**, **objcopy**, **tar**, **gcc**, ...)
- ▶ It provides...
 - a known working configuration for a target board
 - functionality to configure and build Linux **system components** (kernel, bootloader, busybox,)
 - functionality to configure and build the Linux **target system** (network configuration, type of file system to use,)

- ▶ LTIB has been released under the terms of the GNU General Public License (GPL)
- ▶ “Standard Linux” look and feel (**make menuconfig**)
- ▶ More than 200 applications – originating from open source projects and is RPM based
- ▶ LTIB BSPs draw packages from a common pool.
All that needs to be provided for an LTIB BSP is:
 1. cross compiler
 2. boot loader sources
 3. kernel sources
 4. kernel configuration
 5. top level config file ... **main.1kc**
 6. BSP config file ... **defconfig**

LTIB Web Resources

<http://sourceforge.freescale.net/projects/ltib>

The screenshot shows the SourceForge project page for "Linux Target Image Builder - Summary".

Status: NOT LOGGED IN
My SourceForge ▶

Search
Projects ▾
 Require All Words
Search

Project: Linux Target Image Builder
Project Summary ▶
[Project FAQ](#) ▶
Project Admin ▶

SourceForge
[Site FAQ](#) ▶
[Site Docs](#) ▶
About SourceForge ▶
Contact/Support ▶

Collaboration
[Software Map](#) ▶
[New Releases](#) ▶
[Code Snippet Library](#) ▶

This is a simple Linux Board Support Package development/runtime tool.

Project Trove Categorization

- Development Status: 1 - Planning
- Environment: Console (Text Based)
- License: [GNU General Public License \(GPL\)](#)
- Operating System: Linux
- Organization: [Linux Solutions group, SPS NCSG - Networking and Computing Systems Group](#)
- Programming Language: Perl, Unix Shell
- Target system, device, or product: Infrastructure device
- Topic: Build Tools

Project Status

- **Registered:** 2005-Feb-01 11:00 MST
- **Activity Percentile:** 99% [[View project activity statistics](#)]

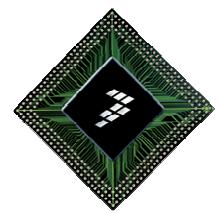
Messages
Looking for useful code or tools? Check out the [Code Snippets](#)!

Latest File Releases
This Project Has Not Released Any Files

Detailed description: The screenshot captures a SourceForge project page for "Linux Target Image Builder". The left sidebar contains links for logging in, searching, and navigating through various SourceForge and project-specific sections like Project Summary, Project FAQ, and Project Admin. The main content area starts with a brief description of the project as a "simple Linux Board Support Package development/runtime tool". It then displays "Project Trove Categorization" with a list of nine categories. Below this is the "Project Status" section, which includes a timeline entry for registration and an activity percentile of 99%. A "Messages" section encourages users to check out code snippets. At the bottom, it states that no files have been released. The overall layout is typical of SourceForge's design from around 2005.



Freescale Linux Board Support Packages



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Freescale Linux BSPs

http://www.freescale.com/webapp/sps/site/overview.jsp?code=CW_BSP&srch

Linux Board Support Packages

Linux Board Support Packages (BSPs) for Freescale Silicon are tested, certified and frozen, ensuring a fully operational tool chain, kernel and board specific modules that are ready to use together within a fixed configuration for specific hardware reference platforms. These BSPs, combined with CodeWarrior tools, provide the foundation you need to begin your project quickly.

All Freescale Linux BSPs include:

Linux kernel & Device drivers
Applications/Services
Libraries
GNU Tools (compilers, linkers, etc.)
Deployment mechanisms

Some features of a chip or an evaluation board may not be enabled by a Linux BSP. Please review the features listed in the "Devices Support" section of each Linux BSP information page. Each Linux BSP link provides detailed information on the version of the kernel, glibc, gcc, etc., as well as information about which applications and services are included within a specific BSP.

BSPs are offered free of charge, "AS IS." Please review the [Linux Technology Support Policies](#) for more information.

- ▶ [BSPs for Power Architecture Technology](#)

- ▶ [BSPs for ColdFire Architectures](#)

Linux Board Support Packages (BSPs) for Freescale Silicon are tested, certified and frozen, ensuring a fully operational tool chain, kernel and board specific modules that are ready to use together ...

- ▶ [BSPs for ARM Architectures](#)

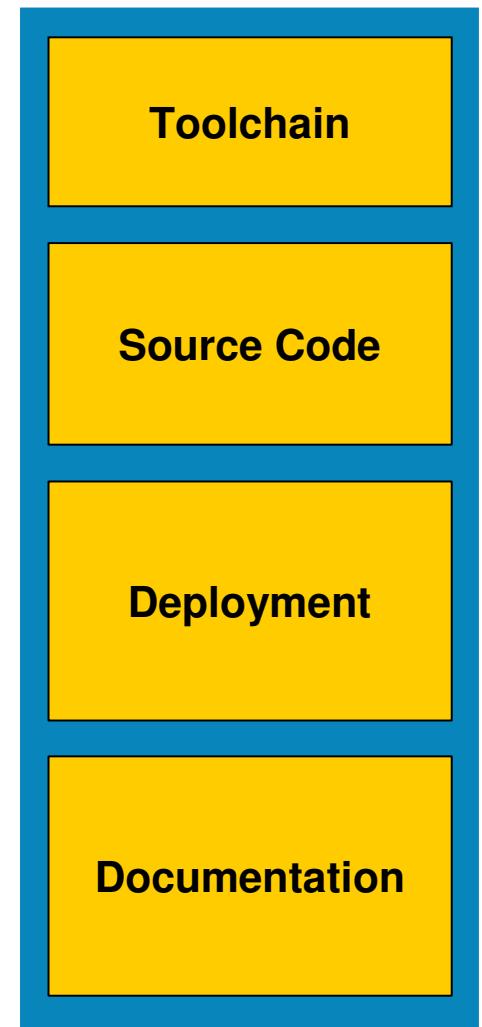
- ▶ [BSPs for Other Architectures](#)

For HP Thin Client support, please contact HP or HP Support .

Freescale Linux BSPs

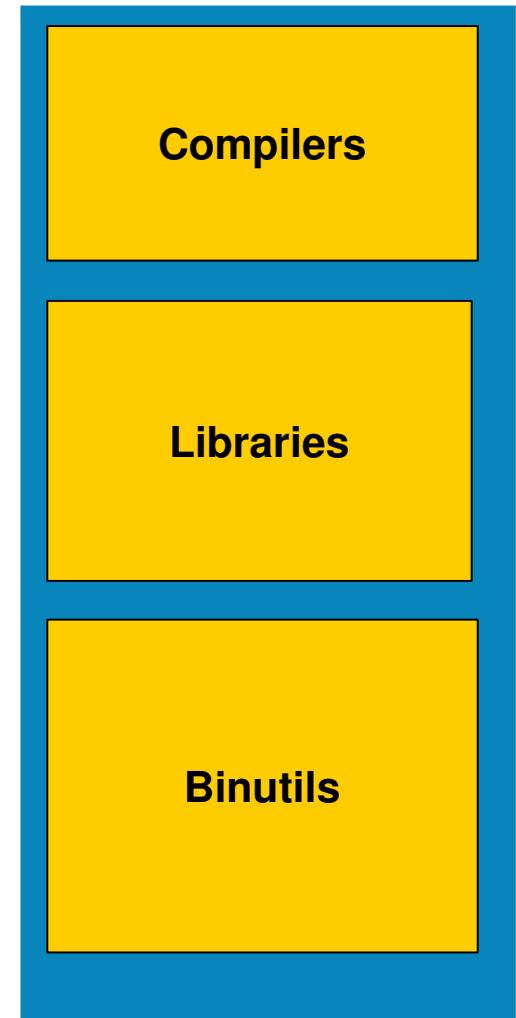
► Typically contain :

- Tools
 - LTIB
- Toolchains
 - Compilers/Linkers
- Source Code
 - Bootloaders (most)
 - Kernel and drivers
 - Applications
- Deployment
 - Automated or instructions
- Documentation
 - BSP usage and hardware docs
 - Device driver docs
 - START_HERE on iso



► GNU Toolchains

- Compilers
 - GCC
 - G++
- Libraries
 - GLIBC
 - **libstdc++**
 - Match to target system libs
- Binutils
 - **ld** (linker)
 - **as** (assembler)



Freescale Linux BSPs

► Freescale Linux Board Support Packages

- BSPs are starting points (also for our 3rd party BSP Linux vendors)
 - Provide basic functionality on listed set of devices
 - They are not production tested or fully optimized
 - They are not intended to be final solutions
- Support Limitations
 - Engineering is 100% engaged in current road map to facilitate new silicon
 - Bugs are verified and accepted
 - Fixes/Patches are worked into future revs of the specific BSP
- Professional Services / Third party developers
 - Feature requests or driver enhancement
 - Training
 - Driver / Application development
 - Support

Load and Run the Image on the Target

▶ Boot from SD

It is a quite common use case, especially useful for demo and test. Put all (bootloader, kernel and root file system) into a removable SD card and boot board from SD card.

▶ Boot from tftp/NFS

During developing phase, it's quite common to load built kernel image via tftp server and then kernel will mount rootfs and other file system image via NFS.

In this case, you need put bootloader in SD, NAND or SPI Nor flash, boot the board from SD, NAND or SPI Nor flash, then configure bootloader to load kernel from tftp server and mount the rootfs from NFS.

▶ Boot from Nor flash

In production phase, we need load bootloader and kernel from in-device storage like Nor flash. In this case, you need put bootloader and kernel, and the file system image into external low-cost large storage (NAND, PATA, SD).

▶ Boot from NAND (Available for i.MX51 PDK only)

In production phase, we need load all (bootloader, kernel and rootfs file system) directly from in-device storage like NAND flash. In this case, you need put not only bootloader but also kernel and file system image into NAND. This is done by using ATK tool.

No matter which method you will use, the 1st thing you need do is to program the bootloader into the board (SPI Nor, NAND or SD).

Kernel boot parameters

kernel parameter	meaning	typical value	Note
console	where to output kernel log by printk	console=ttyMxc0, 115200	COM1 port and 115200bps in default
init	tell kernel where is the "init" file	init=/init or noinitrd	All case Android, "init" in Android is located in "/" instead of in "/sbin"
ip	tell kernel how/whether to get IP address	ip=none, dhcp or static_ip_address	"ip=dhcp" or "ip=static_ip_address" is mandatory in "boot from TFTP/NFS"
mem	how much physical memory can be managed by kernel	mem=456M	All case for Android. In the top of physical memory, 24M is reserved for pmem_adsp (used by VPU driver) and 32M is reserved for pmem_gpu (used by GPU driver). 456M = 512M - 24M - 32M
nfsroot	where is NFS server/directory	rootfs=ip_address:/opt/nfsroot	Used in "boot from tftp/NFS" together with "root=/dev/nfs"
root	indicate where is the root file system	root=/dev/nfs or root=/dev/mmcblk0p1	Used in "boot from tftp/NFS" (i.e. root=/dev/nfs); Used in "boot from SD" (i.e. root=/dev/mmcblk0p1)
rootfstype	indicate file system type of root fs	rootfstype=ext2,ext3 or jffs2	Used in "boot from SD" (if no ramdisk is used for root fs) together with "root=/dev/mmcblk0p1"
video	tell kernel/driver which resolution/depth and refresh rate should be used	video=mxcfb:1024x768-16M@60	Used when display on DVI (i.MX51 BBG2.5 board)
wvga	tell kernel/driver using WVGA panel	wvga	Used when display on WVGA panel (i.MX51 BBG2.5 board)
calibration	tell kernel/driver to do touch panel calibration when 1st boot	calibration	Used when touch panel is needed. i.e. when you display everything on DVI, no need for this.

Adding rootdelay

- ▶ Mounting the root file system on some MMC/SD cards or hard disks may fail.

Ans: this issue might be related to the timing of rootfs storage. Adding “rootdelay=5” command option in kernel boot parameter. It can ensure additional time is reserved for storage initialization before mounting the rootfs. Or, slow down the DRAM clock by redboot command.

Commands

- ▶ IP Address: 10.29.244.102 (target)
- ▶ Netmask.255.255.255.0
- ▶ Gate way: 10.29.244.101
- ▶ Host IP address: 10.29.244.101 (host)

- ▶ Cp zImage to /tftpboot

- ▶ load -r -b 0x100000 zImage
- ▶ Fis create kernel

- ▶ fis load kernel
- ▶ exec -c "noinitrd console=ttyMxc0 root=/dev/nfs nfsroot=10.29.244.101:/tftpboot/ltsip=10.29.244:102:10.29.244.101:255.255.255.0"

Boot board from filesystem on PC(NFS)

- ▶ ./ltib –m shell
- ▶ Mkdir hello
- ▶ Cd hello
- ▶ Vi hello.c
- ▶ Gcc hello.c –o hello
- ▶ Exit
- ▶ Copy the hello executable from hello folder to rootfs

- ▶ ./hello

